Petroleum Engineering 663

Formation Evaluation and the Analysis of Reservoir Performance

Syllabus and Administrative Procedures

Fall 2004

Course Instructor/Supervisor: (Class Meetings: TTh 12:45-2:00 p.m., RICH 302)

Dr. Walter B. Ayers
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Dr. Thomas A. Blasingame

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Text Materials:

- Geology (Ayers) (AAPG 800-364-2274) or www.aapg.org

- Formation Evaluation (Jensen) (.pdf version will be provided)
  — Openhole Log Analysis and Formation Evaluation, Halliburton (.pdf version will be provided)

- Analysis of Reservoir Performance (Blasingame) (SPE 800) 456-6863) or www.spe.org

Reference Materials: Will be handed out or placed on an accessible website as needed.

1. Reference notes.
2. Journal articles.
3. Presentation materials.

Basis for Grade: (components given as percentage of total grade average)

- Geology: Hwk/Quizzes/Projects (13.333 percent), Exam (20 percent).... 33.333 percent
- Formation Evaluation: Hwk/Quizzes/Projects (13.333 percent), Exam (20 percent).... 33.333 percent
- Reservoir Performance: Hwk/Quizzes/Projects (13.333 percent), Exam (20 percent).... 33.333 percent
  total = 100.0000 percent

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 shall 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.
Policies and Procedures: (Continued)

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

The purpose of this course is to provide the student with a working knowledge of the current methodologies used in geological description/analysis, formation evaluation (the analysis/interpretation of well log data), and the analysis of well performance data (the design/analysis/interpretation of well test and production data). The overall course objective is to provide the student with the ability to assess field performance and to optimize hydrocarbon recovery by analyzing/interpreting/integrating geologic, well log, and well performance data.
Course Objectives

The student should be able to perform the tasks given below for each course module.

Course Module 1: Geology (Ayers)
- Draw and label a schematic of a petroleum system; name and describe the organic sources of hydrocarbons.
- Describe the processes of thermal maturation, primary and secondary migration, and hydrocarbon trapping; name and describe 2 types of self-sourcing reservoirs.
- Describe the origin and significance of structural features, including folds, fractures, and traps; describe unconformities; describe the methods and tools used for structural evaluations and modeling.
- Explain and give examples of in-situ stress effects on absolute permeability and permeability anisotropy.
- Characterize a clastic or carbonate reservoir by describing the geometry, orientation, and continuity of sedimentary facies and their relations to flow units and reservoir quality.
- List examples of diagenetic effects on clastic and carbonate reservoir quality.
- Describe porosity-permeability relations in clastic and carbonate reservoirs; give examples of scalar effects on permeability determination.
- Sketch examples of stratigraphic traps.
- Describe the methods, tools, and workflow for developing a reservoir model; compare and contrast deterministic and stochastic reservoir models.

Course Module 2: Formation Evaluation (Jensen)
- Describe and explain the following operational aspects:
  - Logging operation surface and downhole equipment.
  - Logging operation procedures.
- Explain and apply the principles of operation and interpretation of the following logs:
  - Density
  - Spontaneous Potential
  - Sonic
  - Neutron
  - Gamma Ray
  - Resistivity
- Estimate porosity and lithology for the following cases:
  - Monomineral
  - Binary Mixtures
- Apply the following to evaluate saturation:
  - Archie’s laws
  - Pickett plot

Course Module 3: Analysis of Reservoir Performance (Blasingame)
- Derive and apply the analysis and interpretation methodologies for pressure drawdown and pressure buildup tests — for liquid, gas, and multiphase flow systems (i.e., "conventional" plots and type curve analysis). Specifically, the following cases:
  - Apply dimensionless solutions ("type curves") and field variable solutions ("specialized plots") for the following well test analysis case 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 (specialized plots).
    - The pseudopressure and pseudotime concepts for the analysis of well test data for dry gas reservoir systems.
- 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.
- 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).
<table>
<thead>
<tr>
<th>Date</th>
<th>Reading</th>
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<tbody>
<tr>
<td>All assignments (except handouts) from Morton-Thompson and Woods (M-T&amp;W)</td>
<td></td>
</tr>
<tr>
<td>August 31</td>
<td>T (Geol) Introduction; petroleum systems; source rocks; thermal maturation</td>
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<tr>
<td>September 2</td>
<td>R (Geol) Petro. Systems; primary and secondary migration; trapping mechanisms; seals</td>
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<tr>
<td>07 T</td>
<td>(Geol) Struc. Assessment; origin and styles of structural features</td>
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<tr>
<td>09 T</td>
<td>(Geol) Struc. Assessment; folds and fractures; unconformities; thief zones; coring</td>
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<tr>
<td>14 T</td>
<td>(Geol) Res. Characterization; methods of structural evaluation</td>
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<tr>
<td>16 R</td>
<td>(Geol) Res. Characterization; methods of stratigraphic analysis; clastic dep. systems</td>
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<tr>
<td>21 T</td>
<td>(Geol) Res. Characterization, clastic depositional systems</td>
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<tr>
<td>23 R</td>
<td>(Geol) Res. Characterization, carbonate depositional systems; diagenesis</td>
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<tr>
<td>28 T</td>
<td>No Class — 2004 SPE ACTE (Houston, TX)</td>
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<tr>
<td>30 R</td>
<td>(Geol) Res. Characterization; flow units; stratigraphic traps</td>
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**Module 2: Formation Evaluation (Jensen)**

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<tr>
<th>Date</th>
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<tr>
<td>October 05</td>
<td>T (Geol) Res. Characterization; methods of reservoir evaluation and description</td>
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<tr>
<td>07 R</td>
<td>(FrmEvl) Logging procedures and format</td>
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<tr>
<td>07 R</td>
<td>Geology Examination (7-9 p.m. — RICH 302)</td>
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<tr>
<td>12 T</td>
<td>(FrmEvl) Basic lithology measurements: SP and GR</td>
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<tr>
<td>14 R</td>
<td>(FrmEvl) Nuclear tools and interpretation basics</td>
</tr>
<tr>
<td>19 T</td>
<td>(FrmEvl) Acoustic tools and interpretation basics</td>
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<tr>
<td>21 R</td>
<td>(FrmEvl) Crossplots I — Lithology-related functions</td>
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<tr>
<td>26 T</td>
<td>(FrmEvl) Shaly-sand evaluation I — Causes and effects</td>
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<tr>
<td>28 R</td>
<td>(FrmEvl) Shaly-sand evaluation II — Interpretation</td>
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**November 02**

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<tr>
<th>Date</th>
<th>Reading</th>
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<tr>
<td>04 R</td>
<td>(FrmEvl) Resistivity methods I — Principles</td>
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<tr>
<td>09 T</td>
<td>(FrmEvl) Resistivity methods II — Advanced measurements</td>
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<tr>
<td>11 R</td>
<td>(ResPrf) Orientation — Analysis of Reservoir Performance</td>
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<tr>
<td>11 R</td>
<td>Formation Evaluation Examination (7-9 p.m. — RICH 302)</td>
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**Module 3: Analysis of Reservoir Performance (Blasingame)**

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<tr>
<th>Date</th>
<th>Reading</th>
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<tbody>
<tr>
<td>16 T</td>
<td>(ResPrf) Analysis/Interpretation of Well Test Data — &quot;Conventional&quot; Analyses</td>
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<tr>
<td>18 R</td>
<td>(ResPrf) Analysis/Interpretation of Well Test Data — &quot;Type Curve&quot; Analyses</td>
</tr>
<tr>
<td>23 T</td>
<td>(ResPrf) Analysis/Interpretation of Well Test Data — Design/Integration/Analysis</td>
</tr>
<tr>
<td>25 R</td>
<td>No Class — Thanksgiving Holiday</td>
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<tr>
<td>30 T</td>
<td>(ResPrf) Analysis/Interpretation of Production Data — Introduction</td>
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**December 02**

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<th>Date</th>
<th>Reading</th>
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<tr>
<td>07 R</td>
<td>(ResPrf) Analysis/Interpretation of Production Data — Integration/Forecasting</td>
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<tr>
<td>December 15 W</td>
<td>Analysis of Reservoir Performance Examination (8-10 a.m. — RICH 302)</td>
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There is no comprehensive final examination for this course — the timeslot for the final examination will be used as the examination slot for the Analysis of Reservoir Performance (Module 3).
Americans with Disabilities Act (ADA) Statement:
The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact the Department of Student Life, Services for Students with Disabilities in Room B118 of Cain Hall, or call 845-1637.

Aggie Honor Code: [http://www.tamu.edu/aggiehonor/]

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

Definitions of Academic Misconduct:

1. CHEATING: Intentionally using or attempting to use unauthorized materials, information, notes, study aids or other devices or materials in any academic exercise.

2. FABRICATION: Making up data or results, and recording or reporting them; submitting fabricated documents.

3. FALSIFICATION: Manipulating research materials, equipment or processes, or changing or omitting data or results such that the research is not accurately represented in the research record.

4. MULTIPLE SUBMISSION: Submitting substantial portions of the same work (including oral reports) for credit more than once without authorization from the instructor of the class for which the student submits the work.

5. PLAGIARISM: The appropriation of another person's ideas, processes, results, or words without giving appropriate credit.

6. COMPLICITY: Intentionally or knowingly helping, or attempting to help, another to commit an act of academic dishonesty.

7. ABUSE AND MISUSE OF ACCESS AND UNAUTHORIZED ACCESS: Students may not abuse or misuse computer access or gain unauthorized access to information in any academic exercise. See Student Rule 22: http://student-rules.tamu.edu/

8. VIOLATION OF DEPARTMENTAL OR COLLEGE RULES: Students may not violate any announced departmental or college rule relating to academic matters.

9. UNIVERSITY RULES ON RESEARCH: Students involved in conducting research and/or scholarly activities at Texas A&M University must also adhere to standards set forth in University Rule 15.99.03.M1 - Responsible Conduct in Research and Scholarship. For additional information please see: http://rules.tamu.edu/urules/100/159903m1.htm.

Plagiarism Statement:
The materials used in this course are copyrighted. These materials 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 the handouts, unless permission is expressly granted.

As commonly defined, plagiarism consists of passing off as one's own the ideas, words, writings, etc., which 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 regarding plagiarism, please consult the latest issue of the Texas A&M University Student Rules, [http://student-rules.tamu.edu](http://student-rules.tamu.edu), under the section "Scholastic Dishonesty."