Well Logging Methods
PETE 608, Sections 600, 700, and 720
Fall 2013

Instructor

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Instructor Office Hours

Students are encouraged to use office hours during the semester. The instructor’s office hours are as follows:

Group office hours: Tuesdays and Thursdays 5:00 PM-6:00 PM
Location: 401P Richardson

Individual office hours: Tuesdays and Thursdays 6:00 PM-6:30 PM
Location: 401P Richardson

The instructor encourages all the students to attend group office hours to benefit from the discussions and learn from their peers. Distance learning students can join the discussions online.

Additional office hours can be scheduled in advance upon the request from students based on instructor’s availability.

E-Campus Course Website

All the homework assignments, lecture notes, and project assignments will be uploaded on the e-campus webpage designed for this course. Students are responsible to check their university e-mails and e-campus e-mails at least once a day after 6:00 PM for announcements and any required action for the course.
Course Description

The content of Well Logging Methods course is as follows:

- Introduction to well logging methods for determining nature and fluid content of formations penetrated by drilling. The application of well-log interpretation methods will be practiced for the following cases:
  - Core-log integration, rock typing, and resource assessment
  - Quantitative interpretation of well logs to estimate rock and fluid properties, including porosity, net pay thickness, fluid saturations, fluid type/density, volumetric/weight concentrations of minerals, and dynamic petrophysical properties such as permeability and saturation-dependent capillary pressure
  - Well-log interpretation in clay-free, shaly-sand, carbonate, and organic-shale formations
- Theory and physics of well-log measurements
- Development of computer models for well-log analysis

Credit: 3 hrs
Prerequisites: Students are expected to have basic knowledge of petrophysics and Geology.

Teaching Assistants

Alvaro Aranibar
E-mail: alvaro.aranibar@pe.tamu.edu
Office hours: TBA
Location: Richardson 909 (Tentative)

Responsibilities of teaching assistants include:

  a. Helping students with conceptual and technical questions.
  b. Guiding students in homework and project assignments.
  c. Helping students in the preparation for exams.
  d. Training students for using a commercial Formation Evaluation software.

Class/Laboratory Schedule

<table>
<thead>
<tr>
<th>Section</th>
<th>Lecture</th>
<th>Laboratory</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>TR 8:00 AM – 9:15 AM (RICH 302)</td>
<td>TBD</td>
</tr>
<tr>
<td>700</td>
<td>TR 8:00 AM – 9:15 AM (RICH 302)</td>
<td>TBD</td>
</tr>
<tr>
<td>720</td>
<td>TR 8:00 AM – 9:15 AM (RICH 302)</td>
<td>TBD</td>
</tr>
</tbody>
</table>
Suggested References

- Introduction to Wireline Log Analysis, Baker Hughes CD.

References for Introduction to Petrophysics:


Additional Instructional Material

- The instructor will distribute the following material in the class:
  - Formation Evaluation Log Responses Poster, Baker Hughes, 2011.

Handouts and Class PowerPoint Presentations

PowerPoint presentations will be posted on the e-campus website in PDF format. The instructor will not print and distribute the PowerPoint presentations in the class.

Handouts including field examples will be distributed in the class.
Additional Reading Assignments and References

Additional reading assignments and references will be uploaded on the e-campus website under “References” folder.

Useful Websites

- Society of Petrophysicists and Well Log Analysts
- Schlumberger Oil Field Glossary
- Mnemonics Data Search
  [http://www.spwla.org/technical/curve-mnemonics](http://www.spwla.org/technical/curve-mnemonics)
- Log Interpretation Charts, Schlumberger
- Log Interpretation Charts, Halliburton

Course Objectives and Outcomes

At the end of the course, students will be able to:

- Understand the physics of nuclear, electrical resistivity, and acoustic measurements from openhole, cased hole, wireline, and LWD well logs
- Analyze the effect of static (e.g., porosity, volumetric concentration of shale, water saturation, and volumetric concentrations of mineral constituents) and dynamic (e.g., permeability and saturation-dependent capillary pressure) petrophysical properties on well logs
- Evaluate the quality of well logs
- Estimate petrophysical and compositional properties (e.g., porosity, water saturation, volumetric concentration of shale, volumetric concentrations of minerals, permeability, and saturation-dependent capillary pressure) using combined interpretation of well logs and core measurements in different formations such as clay-free, shaly-sand, carbonate, and organic-shale formations
- Estimate elastic properties of the formation using well logs
- Identify rock types for quantifying reservoir quality using well logs
- Make decisions for candidates for perforation and fracturing jobs based on combined interpretation of well logs and core data
- Use a commercial software (e.g., Interactive Petrophysics (IP) and Techlog) for well-log interpretation
Grading Policy

The distribution of the final grade will be as follow:

<table>
<thead>
<tr>
<th>Item</th>
<th>Weight (%)</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework and Project Assignments</td>
<td>35</td>
<td>Thursdays before 11:00 PM</td>
</tr>
<tr>
<td>Class Contribution and quizzes</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>30</td>
<td>Tuesday, October 24, 2013 at 8:00 AM</td>
</tr>
<tr>
<td>Final Exam/Final Project</td>
<td>30</td>
<td>Monday, December 9, 2013 at 1:00 PM</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Grade Cutoffs: The regular university grading scale will be used in determining letter grades.
A: > 90%  B: 89.99% to 80%  C: 79.99% to 70%  D: 69.99% to 60%  F: < 59.99%

Course Policies

- **Class Attendance:** Students are expected to attend every session of the class. Always bring your logging charts, well logs, and a calculator to the class. There is always the possibility of having pop quizzes and solving examples of well-log interpretation in the class, which will not be repeated later.

- **Team Work and Individual Performance:** Collaboration on examinations and assignments is forbidden except when specifically authorized. See Policy on Academic Integrity. For additional information, visit [http://www.tamu.edu/aggiehonor](http://www.tamu.edu/aggiehonor). We have two types of homework and project assignments; individual and group assignments. Individual assignments should be submitted individually. However, group project assignments are team exercises. Collaboration within teams is required; collaboration between teams is forbidden except when specifically authorized. Team reports will be assigned a team grade.

- **Teams:** Teams will be formed during the first week of the semester. Students can choose their team members themselves. The instructor suggests you to team up with students from different majors. Having a combination of on-campus and distance learning students in each team is also highly encouraged. There will be an end-of-term peer-evaluation of individual group members based on their contribution to group work and their collaboration with other group members.

- **Homework and Project Assignments:** Homework and project assignments will be uploaded on e-learning every other week on Thursdays. The deadline for the assignments will be in two weeks after uploading the assignment before 11:00 PM on the e-campus website. Homework assignments will be considered late if they are not turned in before 11:00 PM on the due date. **Late or not, all assignments must be turned in.** Late homework assignments should be e-mailed to the TA responsible for your section and the instructor should be carbon copied (CC) in that e-mail. The e-mailed/late assignments will only receive partial credit. 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.
• **Exams and pop quizzes:** The students who miss any of the exams will not be given any additional exam. The final grade will be re-distributed for the students who miss the midterm exam with valid excuses without including the exam that they missed. Valid excuses include only university-approved reasons in accordance with Texas A&M University Student Rules (see [http://student-rules.tamu.edu/rule07](http://student-rules.tamu.edu/rule07)). Pop quizzes can be taken any time during lecture hours.

• **Laboratory Sessions:** All the laboratory sessions are optional. The purpose of Laboratory sessions is software training. The students will learn the fundamentals of Techlog during laboratory sessions.

• **Grading and Regrading:** The policies regarding grading and regarding of exams and homework and project assignments are as follows:

  a. It is 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 GAT’s, or under the instructor’s direction and supervision, and the decision of the instructor is final.

  d. 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.

  e. Work, which, while correct, cannot be followed, will be considered incorrect and will not be considered for a grade change.

  f. The request for homework and project regrading should be submitted to the instructor within one week from the date returned.

  g. If regrading is necessary for the exams, the student should submit a regrading request to the instructor within one week from the date returned.

• **University Regulations Concerning Attendance, Grades, and Scholastic Dishonesty:** Each student should review the University Regulations concerning attendance, grades, and scholastic dishonesty. In particular, anyone caught cheating on an examination or homework assignment will be removed from the class roster and given an F (failure grade) in the course. Please see Appendix A for more details about Academic Integrity Policy for this course.

• **Americans with Disabilities Act (ADA) Policy Statement (Texas A&M University Policy 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 Disability Services, in Cain Hall, Room B118, or call 845-1637. For additional information visit [http://disability.tamu.edu](http://disability.tamu.edu).

• **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."

- **Aggie Code of Honor:**

  An Aggie does not lie, cheat, or steal or tolerate those who do.
## Tentative Course Schedule*

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>DOW</th>
<th>Type</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>08/27/13</td>
<td>T</td>
<td>Lecture</td>
<td>Introduction to Well Logging, Course Policies</td>
</tr>
<tr>
<td></td>
<td>08/29/13</td>
<td>R</td>
<td>Lecture</td>
<td>Review on Petrophysics and Geology Concepts</td>
</tr>
<tr>
<td>2</td>
<td>09/03/13</td>
<td>T</td>
<td>Lecture</td>
<td>Quick-look well-log interpretation</td>
</tr>
<tr>
<td></td>
<td>09/05/13</td>
<td>R</td>
<td>Lecture</td>
<td>Quick-look well-log interpretation</td>
</tr>
<tr>
<td>3</td>
<td>09/10/13</td>
<td>T</td>
<td>Lecture</td>
<td>Logging environment</td>
</tr>
<tr>
<td></td>
<td>09/12/13</td>
<td>R</td>
<td>Lecture</td>
<td>Data quality control</td>
</tr>
<tr>
<td>4</td>
<td>09/17/13</td>
<td>T</td>
<td>Lecture</td>
<td>Caliper, tension, and temperature logs</td>
</tr>
<tr>
<td></td>
<td>09/18/13</td>
<td>W</td>
<td>Lab**</td>
<td>Introduction to Techlog</td>
</tr>
<tr>
<td></td>
<td>09/19/13</td>
<td>R</td>
<td>Lecture</td>
<td>GR Logs</td>
</tr>
<tr>
<td>5</td>
<td>09/24/13</td>
<td>T</td>
<td>Lecture</td>
<td>Spontaneous Potential (SP) logs</td>
</tr>
<tr>
<td></td>
<td>09/25/13</td>
<td>W</td>
<td>Lab**</td>
<td>Introduction to Techlog</td>
</tr>
<tr>
<td></td>
<td>09/26/13</td>
<td>R</td>
<td>Lecture</td>
<td>Density logs</td>
</tr>
<tr>
<td>6</td>
<td>10/01/13</td>
<td>T</td>
<td>Lecture</td>
<td>PEF logs</td>
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<tr>
<td></td>
<td>10/03/13</td>
<td>R</td>
<td>Lecture</td>
<td>Electrical resistivity logs, electromagnetic properties of rocks</td>
</tr>
<tr>
<td>7</td>
<td>10/08/13</td>
<td>T</td>
<td>Lecture</td>
<td>Examples on $S_w$ assessment, Introduction to Pickett Plot</td>
</tr>
<tr>
<td></td>
<td>10/10/13</td>
<td>R</td>
<td>Lecture</td>
<td>Invasion effects on well logs and annulus effect</td>
</tr>
<tr>
<td>8</td>
<td>10/15/13</td>
<td>T</td>
<td>Lecture</td>
<td>Midterm Exam</td>
</tr>
<tr>
<td></td>
<td>10/17/13</td>
<td>R</td>
<td>Lecture</td>
<td>Neutron porosity logs, gas and mineralogy effects</td>
</tr>
<tr>
<td>9</td>
<td>10/22/13</td>
<td>T</td>
<td>Lecture</td>
<td>Acoustic logs, Basic rock mechanics, Fluid substitution</td>
</tr>
<tr>
<td></td>
<td>10/24/13</td>
<td>R</td>
<td>Exam</td>
<td>Midterm Exam</td>
</tr>
<tr>
<td>10</td>
<td>10/29/13</td>
<td>T</td>
<td>Lecture</td>
<td>NMR logs</td>
</tr>
<tr>
<td></td>
<td>10/30/13</td>
<td>W</td>
<td>Lab**</td>
<td>Introduction to Techlog</td>
</tr>
<tr>
<td></td>
<td>11/31/13</td>
<td>R</td>
<td>Lecture</td>
<td>Pulsed neutron devices and spectroscopy</td>
</tr>
<tr>
<td>11</td>
<td>11/05/13</td>
<td>T</td>
<td>Lecture</td>
<td>Assessment of dynamic petrophysical properties, Conventional vs. new methods</td>
</tr>
<tr>
<td></td>
<td>11/07/13</td>
<td>R</td>
<td>Lecture</td>
<td>Lithology assessment based on well logs, Multi-mineral Analysis</td>
</tr>
<tr>
<td>12</td>
<td>11/12/13</td>
<td>T</td>
<td>Lecture</td>
<td>Well-log interpretation in shaly-sand formations</td>
</tr>
<tr>
<td></td>
<td>11/14/13</td>
<td>R</td>
<td>Lecture</td>
<td>Well-log interpretation in shaly-sand formations</td>
</tr>
<tr>
<td>13</td>
<td>11/19/13</td>
<td>T</td>
<td>Lecture</td>
<td>Well-log interpretation in organic-rich source rocks</td>
</tr>
<tr>
<td></td>
<td>11/21/13</td>
<td>R</td>
<td>Lecture</td>
<td>Rock typing techniques based on well logs</td>
</tr>
<tr>
<td>14</td>
<td>11/26/13</td>
<td>T</td>
<td>Lecture</td>
<td>Evaluation of thinly-bedded formations</td>
</tr>
<tr>
<td></td>
<td>11/28/13</td>
<td>R</td>
<td>Holiday</td>
<td>Thanks giving holiday, No classes</td>
</tr>
<tr>
<td>15</td>
<td>12/03/13</td>
<td>T</td>
<td>Lecture</td>
<td>Image logs, High-angle wells</td>
</tr>
<tr>
<td></td>
<td>12/05/13</td>
<td>R</td>
<td></td>
<td>Reading day, No classes</td>
</tr>
<tr>
<td>Final</td>
<td>12/09/13</td>
<td>M</td>
<td>Exam</td>
<td>Final Exam (1:00 PM – 3:00 PM)</td>
</tr>
</tbody>
</table>

* This course schedule is tentative and subject to change.

** All the laboratory sessions are optional. The purpose of Laboratory sessions is software training. The laboratory schedule is tentative and subject to change.
APPENDIX A: ACADEMIC INTEGRITY POLICY

Rationale – Why I Do What I Do?

Technical competence: I want you to be able to perform well technically as an engineer. I want each of you to be able to perform well individually, not just when you are working with your buddies. It is very unlikely that you and your buddies will end up working together. To remain employed and prosper in your career, you will have to perform individually. In addition to developing technically, deciding that you will not cheat will force you to develop self discipline and time management skills in order to get good grades, which will also help you immensely in your career.

Ethical competence: I want you to be ethically competent. While you may be able to succeed in the short term by being unethical, just as you may get good grades by cheating in school, long-term success can only be achieved with ethical behavior. Don’t think that cheating in school is different from being unethical in the workplace, or that once school is over you will change or won’t need to cheat anymore. If you cheat in school, you won’t think twice about padding your expense account. If you do that, then overstating reserves to increase your bonus won’t bother you. It’s not a big step from there to cooking the books of your company to inflate the value of your stock options. I don’t want any Aggies involved in the next Enron debacle, and it starts with cheating in school.

Fairness: Those who cheat have an unwarranted advantage over those who don’t. I want to be fair to those who don’t cheat.

The Aggie Honor Code: As a Texas A&M University faculty member, I am also bound by the Aggie Honor code, which includes that I will not tolerate those who cheat.

What I Will Do?
For the reasons above, and because I feel quite strongly about them,
1. I will do everything I reasonably can to prevent cheating. I don’t do everything I possibly can because this would be a full-time job.
2. Because I can’t do everything possible to prevent cheating, when I determine a cheating violation has occurred I will (a) report it through the Aggie Honor System Office (AHSO), and (b) punish to the full extent that I am able to.

What Constitutes Academic Dishonesty?
You may be surprised at what is considered academic dishonesty. For example,
• During an examination, looking at another student’s examination or using external aids (for example, books, notes, calculators, conversation with others, or electronic devices) unless specifically allowed in advance by the instructor.
• Acquiring answers for any assigned work or examination from any unauthorized source. This includes, but is not limited to, using the services of commercial term paper companies, purchasing answer sets to homework from tutoring companies, and obtaining information from students who have previously taken the examination.
• Collaborating with other students in the completion of assigned work, unless specifically authorized by the instructor teaching the course.
• Knowingly allowing another to copy from one’s paper during an examination or test. See http://aggiehonor.tamu.edu/Descriptions/ for a complete list.

Reporting an Academic Violation – What Happens?
• I will report the violation to the AHSO, regardless of the magnitude of the violation.
• The report is submitted online and includes (1) the details of the violation, (2) an election to handle autonomously or refer to the Honor Council, (3) specification of sanction, and (4) student acknowledgement of acceptance/rejection of violation and/or sanction.
• I will usually handle the first offense autonomously; e.g., I decide the sanction. My minimum sanction will usually be a one-letter-grade reduction in your course grade. The maximum sanction I can and will award is an F* (failure of the course and notation of “FAILURE DUE TO ACADEMIC DISHONESTY” on transcript until cleared by taking the Academic Honesty Remediation Course).
• I will usually include taking the Academic Honesty Remediation Course as part of the sanction. This is a three-class, one-month course on academic integrity. I will usually give you one semester to take the course. If you do not take the course by this time your grade will be changed to an F*.
• Importantly, you are now logged into the AHSO system. If there is a second violation, in any course, you will automatically go before the Honor Council, and you will likely be expelled from the university.
• Note that upper division students found guilty of a violation are ineligible to graduate with honors. I will treat students giving unauthorized help the same as students receiving unauthorized help.
• In all cases, you have the right to appeal to the AHSO.

Final Words
Please understand that none of this is personal. My desire is for academic integrity, regardless of who you are. I want you all to do well. I just want you to do it honestly. You will be a better engineer because of it.
You now know what I will do. Don’t claim ignorance or ask for a second chance if you are caught. I have given the consideration I will give by telling you in advance and in no uncertain terms what I will do so that you can make an informed decision about cheating.