Syllabus CH EN 6181 – Drilling and Completion
Fall 2014

Faculty
John McLennan
Room 2292, Merrill Engineering Building (MEB) or EGI, Suite 300, 423 Wakara Way
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jmclennan@egi.utah.edu
Office Hours: Any time or by appointment

Prerequisites
Confirm with Graduate Advisor

Additional Course Information
Additional course information will be provided as needed throughout the semester and will be available on Canvas.

Homework Policy
Homework is due at the start of class on the day specified on the homework assignment.
No late homework will be accepted since solutions will be posted on Canvas after class the day assignments are due. If you cannot make class the day your assignment is due, you should turn it in early or make arrangements to have someone submit it for you.

Exam Policy
No make-up exams will be given. If you absolutely cannot attend the scheduled examination, please see me before the exam to try and make arrangements.

Grading
40% Homework
20% Project
20% Mid-Term Exam
20% Final Exam
Exams will be open book, open notes, open homework

Final Exam
Per University Academic Calendar – There is some ambiguity in the calendar. For the time being presume 1:00 to 3:00 p.m. on December 19 in the regular room (WEB 2460)

Summary:
Drilling and Production Operations highlights the basics of accessing underground hydrocarbon or other energy resources – applied drilling engineering. This introductory course is an overview of surface and subsurface activities associated with drilling new wells or deepening existing wells. Basic rock and fluid mechanics principles will be summarized as they are related to the stability of a wellbore during drilling, the efficient removal of cuttings and subduing formation pressure. Newer technologies (directional drilling, pinnate drilling, and underbalanced drilling) will be introduced. Environmental awareness and procedures for
minimizing footprint and impact on the environment and stake holders will be considered. Principles of well control will be introduced.

After a well is successfully drilled, it is completed. This means ensuring that the well is stable over the duration of its life and that there are multiple hydraulic seals to prevent in-situ fluids from reaching the surface. This is usually done by running and cementing casing, although uncased (openhole) completions are becoming more common when wellbore stability is not an issue. After the well is stabilized, it is necessary to re-establish communication between the producing formation(s) and the wellbore – usually with perforating the casing and cement sheath with shaped charges (perforating). Finally, particularly in low permeability formations hydraulic fracturing is carried out to stimulate production. In some cases, formations may simply be exposed to acid to remove drilling damage or other damage that reduces hydrocarbon inflow. Finally, offshore operations will be summarized.

**Textbook:**

This textbook is available from the Society of Petroleum Engineers. There are sometimes reduced rates for SPE members and if you are not a member you should qualify as a student – student membership is subsidized (~$15 USD). To join SPE, use the following hyperlink: [http://www.spe.org/students/join.php](http://www.spe.org/students/join.php). To order the textbook, go to the following hyperlink: [http://store.spe.org/Drilling-Completions-C11.aspx](http://store.spe.org/Drilling-Completions-C11.aspx) Notice that there is
a digital and a softcover version. Some students in the past have found navigation in the softcover version more convenient. The price for an SPE member is ~95 USD.

- **Petroleum Well Construction**, Economides et al., 2000 (optional). This will be uploaded by the instructor.
- Other materials will be distributed in class or are available on line.

**Course Objectives:**

1. Understanding the scope of standard activities on a well location before first production – drilling, cementing, and stimulation.
2. Appreciating the environmental considerations, regulations and the stakeholder issues associated with well construction.
3. Recognizing basic geologic input that is critical to effective and economic drilling operations.
4. Exposure to basic calculations and tools for well control, cementing, stimulation design and production estimations.

**Tentative Course Curriculum:**

**Module 1: Before Drilling**
- a) Introduction
- b) Permits
- c) Rudimentary Economics (AFE)
- d) Site Preparation
- e) Health, Safety and Environment (HSE)
- f) Introduction to Stresses and Pore Pressure

**Module 2: Drilling and Well Servicing Structures (Rig Selection)**
- a) Onshore
- b) Offshore
- c) Design Considerations
- d) Hoisting Equipment
- e) Rotary Equipment
- f) Mud Pumps and Associated Equipment

**Module 3: Hardware**
- a) Drillstring Composition and Design
- b) Bits and Downhole Tools
c) Downhole Motors
d) Directional Drilling
e) Well Pressure Control

**Module 4: Drilling Muds and Completion Fluids**

a) Oil- and Water-Based Fluids
b) Additives
c) Hydraulics
   a. Lifting Capacity of Rig
   b. Static Pressure Calculations
   c. Circulating Pressure Calculations
d) Surge and Swab Pressures
e) Well Control
d) Underbalanced Drilling

**Module 5: Drilling and Logging Operations While Drilling**

a) Drillstring Design
b) Bit Types and Selection
c) Mud Logging
d) MWD and LWD
e) Well Testing While Drilling

**Module 6: Rock Mechanics in Wellbore Construction**

a) Wellbore Stability
b) Bit Mechanics (energy considerations)
c) Cuttings Reinjection
d) Leaky Wellbores

**Module 7: Directional Drilling**

a) Vertical, Deviated, Horizontal and Multilateral Well Configurations
b) Directional Drilling Mechanics and BHAs
c) Rotary Steerable Technology
d) Casing Drilling
e) Mud Motors
f) Telemetry

**Module 8: Casing Design**
a) Main Factors Affecting Completion Design
b) Primary Completion Configurations
c) Selecting Casing Points and Casing Type

Module 9: Cementing Design
a) Basics of Casing Design – Including Calculations
b) Elementary Cementing – Including Calculations

Module 10: Cementing Design
a) Introduction to Perforating

Module 11: Hydraulic Fracturing
a) Rock Mechanics Overview
b) Design Considerations (Dimensionless Conductivity)
c) Materials (Fluids, Additives, Proppant)
d) Pumping Equipment
e) Planning, Execution and Back-Analysis

Module 12: Acidizing
a) Chemistry Overview
b) Design Considerations (Volumes, Real-time Evaluations)
c) Materials (Fluids, Additives, Proppant)
d) Pumping Equipment
e) Planning, Execution and Back-Analysis

Module 13: High Permeability Completions
a) Production Formulae and Skin
b) Gravel Packs and Frac Packs
<table>
<thead>
<tr>
<th>Day</th>
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<th>Reference</th>
<th>Topic of Discussion</th>
<th>Special Notes</th>
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<tbody>
<tr>
<td>Tuesday</td>
<td>August 26</td>
<td>Chapters 1 and 2</td>
<td>Module 1: Before Drilling (Permitting and Site Preparation) and Introduction to In-Situ Stresses and Pressure</td>
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<tr>
<td>Thursday</td>
<td>August 28</td>
<td>Chapter 1</td>
<td>Module 2: Drilling Equipment and Structures (rigs)</td>
<td>Assign Homework 1</td>
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<tr>
<td>Tuesday</td>
<td>September 2</td>
<td>Various</td>
<td>Module 3: Introduction to the Drillstring and Bottomhole Assembly (bits, collars, and mud motors ...) and well control equipment. This will be introductory. More will follow.</td>
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<td>Thursday</td>
<td>September 4</td>
<td>Chapter 3</td>
<td>Module 4: Drilling Fluids (Purpose and Water-Based Muds)</td>
<td>Homework 1 Due</td>
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<td>Assign Homework 2</td>
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<td>Tuesday</td>
<td>September 9</td>
<td>Chapter 3</td>
<td>Module 4: Drilling Fluids (Oil-Based Muds and Lost Circulation)</td>
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<td>Thursday</td>
<td>September 11</td>
<td>Chapter 5</td>
<td>Module 4: Drilling Hydraulics - Static Fluid &amp; Pipe</td>
<td>Assign Project 1</td>
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<td>Assign Homework 3</td>
<td>Homework 2 Due</td>
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<td>Tuesday</td>
<td>September 16</td>
<td>Chapter 5</td>
<td>Module 4: Drilling Hydraulics - Drilling &amp; Circulating as well as Underbalanced and Managed Pressure Drilling</td>
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<td>Thursday</td>
<td>September 18</td>
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<td>Guest Lecturer: Dr. Michael Abrams - Petroleum Geochemistry for the Petroleum Systems Analyst Time Change for this Lecture 9:00 – 10:30 plus as required.</td>
<td>Homework 3 Due</td>
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<td>Assign Homework 4</td>
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<tr>
<td>Tuesday</td>
<td>September 23</td>
<td>Chapter 9</td>
<td>Module 5: Drillstring Design</td>
<td>Homework 4 Due</td>
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<tr>
<td>Thursday</td>
<td>September 25</td>
<td>Chapter 6</td>
<td>Module 5: Bit Types and Selection</td>
<td>Assign Homework 5</td>
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<td>Tuesday</td>
<td>September 30</td>
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<td>Module 5: Measurements While Drilling</td>
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<td>Thursday</td>
<td>October  2</td>
<td>Chapter 2</td>
<td>Module 6: Rock Mechanics – Review of Stress and Pore Pressure, Wellbore Stability, Bit Mechanics</td>
<td>Homework 5 Due&lt;br&gt;Assign Homework 6</td>
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<td>Tuesday</td>
<td>October  7</td>
<td>Chapter 2</td>
<td>Module 6: Rock Mechanics – Leaky Wellbores, Cuttings Reinjection ...</td>
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<td>Thursday</td>
<td>October  9</td>
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<td>Mid-Term Exam</td>
<td>Homework 6 Due&lt;br&gt;Assign Due 7</td>
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<td>Tuesday</td>
<td>October 14</td>
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<td>Fall Break</td>
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<td>Thursday</td>
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<td>Tuesday</td>
<td>October 21</td>
<td>Chapter 8</td>
<td>Module 7: Directional Drilling &lt;br&gt;Project 1 Presentations</td>
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<td>Thursday</td>
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<td>Module 8: Casing Design</td>
<td>Homework 7 Due&lt;br&gt;Assign Homework 8</td>
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<td>Tuesday</td>
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<td>Module 8: Casing Design</td>
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<td>Thursday</td>
<td>October 30</td>
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<td>Module 9: Cementing</td>
<td>Homework 8 Due&lt;br&gt;Assign Homework 9</td>
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<td>Tuesday</td>
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<td>Chapter</td>
<td>Module 9: Cementing</td>
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<td>Thursday</td>
<td>November  6</td>
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<td>Module 10 – Perforating</td>
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<td>Module 10 Perforating</td>
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<td>Thursday</td>
<td>November 13</td>
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<td>Module 11 Hydraulic Fracturing</td>
<td>Assign Project 2</td>
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<td>Tuesday</td>
<td>November 18</td>
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<td>Module 11 Hydraulic Fracturing: Partial Working Session on Project 2 in ICC (Industrial Computing Center, in Southeast Corner of Merrill Engineering Building on second floor)</td>
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<td>Thursday</td>
<td>November 20</td>
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<td>Working Session on Project 2 in ICC (Industrial Computing Center, in Southeast Corner of Merrill Engineering Building on second floor)</td>
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<td>Tuesday</td>
<td>November 25</td>
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<td>Module 12: Acidizing</td>
<td>Assign Homework 10</td>
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<td>Thursday</td>
<td>November 27</td>
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<td>Thanksgiving – No Lecture</td>
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<td>December 2</td>
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<td>Module 13: High Permeability Completions</td>
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<td>Project 2 Presentations</td>
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<td>Thursday</td>
<td>December 11</td>
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<td>Review Session</td>
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<td>Thursday</td>
<td>December 15-19</td>
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<td>Final Exam PLEASE CONFIRM ON YOUR OWN</td>
<td>Confirm date/time on your own!!</td>
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