ES486 Petroleum Geology
Mid-Term Exam Study Guide
Winter 2021

Exam Format: The midterm exam will occur on Thursday Feb. 11, 2021, worth a total of 100 points. Exam questions will be comprised of multiple choice, true/false and short answer-fill in blank; along with short and long answer essay, and lab-style problem solving. Two-Part Exam; Part 1 - Closed Book, qualitative exam questions, short answer essay – terms and definitions, draw sketches, long answer essay – "compare and contrast", "discuss", "explain". Part 2, Open Book, lab-style problem solving, you will be able to use all of your class resources to solve math-based, lab-style problems.

Exam Logistics: The online exam will be available as a link at the top of the General Section of the ES486 Moodle course shell, between 8 AM and 11 PM on exam day. Once a student begins the exam, it will be timed for 2 hours. You may begin the exam at any time between 8 AM and 11 PM, but make sure that once you start it, you have enough time before the 11 PM cut-off availability to complete the exam. The exam questions will be submitted only once, with no opportunities for resubmissions. The Professor will be manually grading your exams and reviewing your answers, in addition to the automated Moodle grading tools; typos and misspelled words in short answer will be evaluated for correctness in content. Additional testing accommodations are possible by prior arrangement with the professor.

Study Tips

- go through the web site, look at the figures and slide shows, compare to notes
- review the video resources and exercise review sheets; check the lab answer keys for review
-review textbook summary questions / answers
- use study guide in combination with notes
- go back through the in class / lab exercises, make sure you can work the math / units
- spend a couple days studying, the exam will be essay and there is much material.
- don't wait until the last minute!
- carefully go through the notes, some of the material we briefly discussed, but did not spend much time on in class... but the notes will give you the detail
-finish all your lab exercises and assignments before taking the exam!!! Lab questions will appear.
-Exam format: Part 1. Closed book short answer / essay. Part 2. Open-book lab-style problem solving.
NOTE: I would spend a minimum of 5 hours studying for this exam if I wanted to do well.

Exam Study Resources (Readings and Class Notes from Weeks 1 through 5)

- Text Reading: Chapter 1 – Introduction

https://people.wou.edu/~taylors/es486_petro/text/Ch1_intro.pdf

- Class Notes 1. Introduction to Petroleum Geology

https://people.wou.edu/~taylors/es486_petro/1_Introduction.pdf

- Class Notes 2. Overview of Basic Physical Principles

https://people.wou.edu/~taylors/es486_petro/physrevw.pdf

- Class Notes 3. Introduction to the Earth System

https://people.wou.edu/~taylors/es486_petro/Intro_Earth_System_Science.pdf

- Text Reading: Chapter 2 - Properties of Petroleum

https://people.wou.edu/~taylors/es486_petro/text/Ch2_properties.pdf

- Text Reading: Sedimentary Rocks

https://people.wou.edu/~taylors/es486_petro/text/Sed_Rocks_Review.pdf

- Class Notes 4. Review of Sedimentary Rocks

https://people.wou.edu/~taylors/es486_petro/2_sedimentary_rock_review.pdf

- Class Notes 5. Overview of Stratigraphy and Depositional Systems

https://people.wou.edu/~taylors/es486_petro/3_Overview_Stratigraphy_Depositional_Systems.pdf

- Class Notes 6. Reservoir Fluids: Properties of Formation Water, Oil and Gas

https://people.wou.edu/~taylors/es486_petro/4_Reservoir_Fluids.pdf

- 6A. Physical Principles in Fluid Environments

https://people.wou.edu/~taylors/es486_petro/4A_Physical_Principles_Fluids.pdf

- Text Reading: Ch. 4 - Subsurface Environments

https://people.wou.edu/~taylors/es486_petro/text/Ch4_Subsurface.pdf

- Class Notes 7. Reservoir Fluids: Properties of Formation Water, Oil and Gas

https://people.wou.edu/~taylors/es486_petro/4_Reservoir_Fluids.pdf

- Text Reading: Ch. 5 - Petroleum Generation

https://people.wou.edu/~taylors/es486_petro/text/Ch5_generation.pdf

- Class Notes 8. Source Rocks: Generation and Migration of Petroleum

https://people.wou.edu/~taylors/es486_petro/5_source_rocks_generation_petroleum.pdf

- Text Reading: Ch. 6 – Reservoirs

https://people.wou.edu/~taylors/es486_petro/text/Ch6_reservoir.pdf

- Class Notes 9. Reservoir Properties

https://people.wou.edu/~taylors/es486_petro/6_Reservoir_Characterization.pdf

Review Questions from Homework Assignments:

- Task 2-1. Reading Review Questions - Ch. 2 Petroleum Properties
- Task 2-2. Video Review Questions: Earth Revealed Introduction to Sedimentary Rocks
- Task 2-3. Key Word Search Assignment: Overview of Sedimentary Rocks, Stratigraphy, Basins
- Task 3-1. Reading Review Questions Chapter 3 Subsurface
- Task 3-2. Video Review Questions Earth Revealed Living with Earth
- Task 3-4. Lecture Review Questions Univ. of Delft Carbon Cycle
- Task 4-1. Reading Review Questions: Chapter 5 Petroleum Generation and Migration
- Task 4-4. Lecture Review Questions Univ. of Delft: Oil and Gas Composition
- Task 5-1. Reading Review Questions: Chapter 6 Reservoirs
- Task 5-2. Video Review Exercise: Earth Revealed Geologic Time
- Task 5-3. Lecture Review Questions Univ. of Delft: Oil Migration from Source to Sink
- Task 5-5. Reading Review Questions: Key Terms in Stratigraphy and Lithologic Correlation

Lab Exercises

Task 1-3. Introduction to Quantitative Analysis Lab Exercise
Task 2-4. Introduction to Engineering Principles and Rock Properties (Complete the following questions Q 1,3,4,5,7,9, 11, 21)
Task 3-3. Sedimentary Rocks Review Lab Exercise
Task 4-2. Fluid Pressure Exercise
Task 4-3. Ideal Gas Law Exercise
Task 5-4. Lab Exercise: Geologic Time

Review Selley "Essentials of Petroleum Geology" Introductory Text Chapters;

Chapter 1 Introduction;
"Creekology"
Anticline Theory
Five Conditions of Petroleum Accumulation
- Source
- Reservoir
- Trap and seal
- Timing
- Preservation

Geology and Petroleum
Biology and Petroleum
Exploration vs. Production
Drakes Well, Titusville PA

Chapter 2 Properties;
Hydrocarbon gases
Natural gases
Organic matter
Inert gas
Methane-ethane-propane
Helium
Carbon dioxide
Gas hydrates
Crude Oil
API Gravity
Paraffins-Napthenes-Aromatics-Asphaltines
"Cracking" Distillation
Sweet crude-sour crude

Chapter 4 Subsurface Environment
Subsurface water
Connate-meteoric-juvenile water
Eh – Ph
Concentration
ppt, ppm, ppb
Brine water
Salinity
Total dissolved solids
Subsurface temperatures
Geothermal gradient
Bottom hole temperature
Thermal conductivity
Porosity / compaction
Formation temperatures
Subsurface pressures
Hydrostatic pressure
Lithostatic pressure
Oil-water contact
Pressure gradient
Artesian pressure
Structural pressure

Key Words from Notes and Readings
(Web links provided below)

Introduction
https://people.wou.edu/~taylors/es486_petro/1_Introduction.pdf

hydrocarbons
phases: solid-liqud-gas
crude oil
natural gas
kerogen
gas hydrate
tars and resins
sedimentary basin
biogenic sediment
geologic time
thermal maturity
source rock/sediement
reservoir
seals, cap rock
trap
Conditions for Petroleum
- Biogenic sediments
- Source Rock
- Thermogenic Maturation
- Reservoir-Seal-Trap

Dry gas/ wet gas
Sweet vs. sour crude
Inert gases
Light Oil vs. Heavy Oil
Hydrocarbon composition Wt%
- Paraffin
- Napthene
- Aromatics
- Asphaltics

Crude Distillates
Petroleum Engineering
Chemical Engineering
"Cracking"
Exploration-Production-Refining-Marketing
Historical Perspectives on Oil
Drakes Well

Basic Principles Intro to Earth System
https://people.wou.edu/~taylors/es486_petro/Intro_Earth_System_Science.pdf

Earth System Science
Environmental Spheres
Atmosphere
Biosphere
Lithosphere
Hydrosphere
Lithosphere-Tectonic Plates
Geothermal-Gravity-Solar
Matter-Energy-Force
Kinetic Energy
Potential Energy
Open System-Closed System
Transfer of Mass
Transfer of Heat
Mass-Energy-Heat Flux
Hydrologic Cycle
Carbon Cycle
Rock Cycle

Tectonic Cycle

Physical Principles
https://people.wou.edu/~taylors/es486_petro/4A_Physical_Principles_Fluids.pdf

Mass-Length-Time-Temperature
Force-Energy-Work
Motion-Velocity-Acceleration
Acceleration due to Gravity
Pressure
Power
Density
Weight Density = Specific Weight
Viscosity
Heat-solid-liquid-gas
Density-Buoyancy
Temperature-Density Relations
Newtons-Joules-Pascals-Watts
Periodic Chart
Atomic Model
Neutrons-Protons-Electrons
Atomic Number
Atomic Mass
Isotope
Formula Weight
Mole

Review of Sedimentary Rocks
https://people.wou.edu/~taylors/es486_petro/2_sedimentary_rock_review.pdf

weathering
sediment
sediment transport
sediment burial
lithification
fossil
erosion
lithification
compaction
cementation
Sed. Rock types
    detrital
    biochemical
    chemical
sediment size fractions
    gravel
    sand
    silt
    clay
grain shape
grain sorting
rock types
    sandstone
    conglomerate
    shale
    limestone
    evaporites
crystalline vs. microcrystalline
    coal
clastic / nonclastic
marine
nonmarine
fluvial
lacustrine
glacial
Sedimentary Features
sedimentary structures
methods of transport
bedload
suspension
dissolved load
cross-stratification
graded bedding
reverse grading
normal grading
asymmetric ripples
symmetric ripples
flute casts
cast vs. mold
mudcracks
raindrop imprints
paleocurrents

Overview of Stratigraphy and Depositional Systems
https://people.wou.edu/~taylors/es486_petro/3_Overview_Stratigraphy_Depositional_Systems.pdf

Geologic time / Earth History
Age of Earth
Stratigraphy
Stratigraphic Record
Geologic Column / Time
    PreCambrian Era
        Archeozoic
        Proterozoic
    Paleozoic Era
        Cambrian
        Ordovician
        Silurian
        Devonian
        Mississippian
        Pennsylvanian
        Permian
    Mesozoic Era
        Triassic
        Jurassic
        Cretaceous
    Cenozoic Era
        Tertiary
        Quaternary
Law of Original Horizontality
Law of Superposition
Law of Uniformitarianism
Law of Cross-Cutting Relations
Law of Faunal Succession
Walthers Law
Relative Geologic Dating
Absolute (numerical) Dating
Half Life
Parent-Daughter Isotopes
Radioactive decay
Horizontal/vertical bed relations
Dike-Sill-Fault
Lithostratigraphy

Biostratigraphy
Seismic Stratigraphy
Index Fossils
Unconformity
Angular Unconformity
Nonconformity
Conformable Strata
Interfingering Strata
Diastem
Lacuna
Paraconformity
Transgression-Regression
Onlap-Offlap
Eustacy
Sedimentary Basins
Facies
Formation
Member
Bed
Marine-NonMarine
Fluvial
Lacustrine
Deltaic
Littoral
Beach-Barrier
Lagoonal-Estuarine
Tidal Flat
Shelf
Slope
Abyssal Plain
Reef

Subsurface Fluids and Conditions
https://people.wou.edu/~taylors/es486_petro/4_Reservoir_Fluids.pdf

Water-Oil-Gas
Connate-Meteoric-Juvenile
Fluid Density-Buoyancy
Brines
Formation Water
Salinity-Concentration-Total Dissolved Solids
Mass Percent-PPT-PPM-PPB
Solute-solvent
Crude Oil
C-H ratios
Parrafin-Napthene-Aromatics
Asphaltine
Barrels- bbl
Example Parrafin compounds
Example Napthenes-Aromatics
Molecular models
Oil Composition
Density-API Gravity Index
Viscosity-Temperature
Temperature-Volume-Density
Heat Content (BTU, Calorie)
Natural Gas
Dissolved vs. Free
"inflated oil"
Ideal Gas Law

Hydrocarbon Properties
http://www.wou.edu/las/physci/taylor/es486_petro/Hydrocarbon_Properties_Heat_Density_Viscosity.pptx
Heat-Energy
Calorie
Joule
BTU
Thermal heat value
Density-specific gravity
API gravity index
Viscosity
Volume – bbl = barrel = 42 gal

Subsurface Temperature and Pressure
http://www.wou.edu/las/physci/taylor/es486_petro/4B_Subsurface Temperature and Pressure.pdf
Heat-Energy
Heat flux
Heat flow
Geothermal gradients
Thermal conductivity
Pressure
Overburden pressure
Lithostatic pressure
Hydrostatic pressure
Pressure gradients
Formation temperature
Formation pressure
Bottom hole temperature
Bottom hole pressure
Thermal maturation

Chapter 5 Generation & Migration
https://people.wou.edu/~taylors/es486_petro/5_source_rocks_generation_petroleum.pdf

Organic vs. Inorganic Source
Mantle hydrocarbon
Meteorite hydrocarbon
Igneous hydrocarbon
Sedimentary hydrocarbon
Carbon cycle
Photosynthesis
Bacterial decay
Protein-carbohydrate-lignin-lipids
Plant vs. animal carbon
Biomass production
Organic preservation
Organic productivity Marine
Productivity NonMarine
kerogen
Bitumen
Diagenesis
Type I-II-III Kerogen
Maturation
Catagenesis
Metagenesis
Paleothermetry
Vitrinite Reflectance
Biogenic gas production
Thermogenic gas production
Primary Migration
Secondary Migration
Overpressure/microfractures
Oil Expulsion

Reservoirs (Selley Chapter 6)
https://people.wou.edu/~taylors/es486_petro/6_Reservoir_Characterization.pdf

Porosity
Effective porosity
Total porosity
Primary porosity
Secondary porosity
Intergranular porosity
Fracture porosity
Solution porosity
"Vuggy Porosity"
Intercrystalline porosity
Cementation/compaction
Diagenesis
permeability
permeability vs. porosity vs. lithology
Darcy's Law
Millidarcy
100 md reservoir threshold
Viscosity
Permeameter
Horizontal vs. vertical permeability
Homogenous vs. heterogeneous
Anisotropic vs. Isotropic
Artesian Reservoirs (gushers)
Texture vs. Permeability vs. Porosity
Grain Shape-Sorting-Grain Size
Clay/shale vs. Sand/Sandstone
Grain packing; grain fabric
Sandstone/Limestone
Reservoirs
Shale/Mudstone Seals
Diagenesis effects on Reservoir
Clay alteration
Authigenic Clay
Feldspar degradation
Porosity loss vs. compaction
Cementation vs. porosity
Depth-compaction curves
Clay diagenesis / dewatering
Carbonate diagenesis
Dolomitization
Calcite-Dolomite Transformation
Reservoir shape / continuity
Sheet vs. ribbon vs. pod

Quantitative / Lab Skills

Quantitative Methods
Perform basic unit conversions-unit algebra-solve quantitative word problems
Process Rate Calculations
calculate potential energy, kinetic energy, force, weight, stress
pressure-depth calculations
application of idea gas law to subsurface gas accumulations
calculation of basic engineering properties of rocks
porosity-density-specific weight
Sedimentary Rocks
what about the three diff. types of sed. rocks?
Can you estimate: grainsize? sorting? grading? angularity?
What about basic paleocurrent directions? How can you tell which way the fluid was moving when the sediment was deposited?
What about recognizing some basic sedimentary structures?
Associating a specific rock type to a possible sedimentary environment?
How does transport energy relate to grain size of deposits? (e.g. would you find boulders in the deep ocean?)
What are the basic marine and nonmarine sedimentary environments?
What are sedimentary structures and how are they used to reconstruct sedimentary environments?
What type of environment do the various sed. rock types form? e.g. sandstone, conglomerate, evaporites, coal, mudcracks, limestone, etc. where would these rocks form at the earth's surface?
Review the lab answer keys on class web site!

Big Concepts for Long-Answer Essay Questions
What are the primary types of hydrocarbons?
What are the criteria necessary for the generation and accumulation of hydrocarbons in subsurface?
What compounds are petroleum and natural gas composed of? What are the basic carbon families and their general molecular compositions? What is the process necessary to find and produce petroleum-related products for industry? What is the basic refining process? How does transport energy relate to grain size of deposits? (e.g. would you find boulders in the deep ocean?) What are the fundamental energy sources of the earth system How do force-energy-pressure relate to the subsurface environment? What are the temperature and pressure conditions like in the subsurface environment?
What are the fundamental components of the Earth System?
How do the study of sedimentology and stratigraphy relate to petroleum geology?
What are the basic laws and principles of stratigraphy used to analyze sedimentary rocks?
What are the basic marine and nonmarine sedimentary environments?
What are sedimentary structures and how are they used to reconstruct sedimentary environments?
What type of environment do the various sed. rock types form? e.g. sandstone, conglomerate, evaporites, coal, mudcracks, limestone, etc. where would these rocks form at the earth's surface?
How do sediments accumulate over time? How is time recorded in the rock record?
What are the primary fluids contained in the subsurface environment? Relative abundance and composition of each? What is the chemical composition of formation water? Crude oil? Natural gas?
What are the key properties used to characterize petroleum and natural gas?
How is petroleum generated? What are the geologic conditions necessary? Discuss the global carbon cycle in the context of petroleum geology. What are the sources of organic materials in petroleum? Chemical composition? What are the steps in petroleum generation? The thermal maturation process?
What are the essential properties for Reservoir rocks? What types of sedimentary rocks are associated with reservoirs?