The SPE Technical Knowledge for Graduating Engineers Matrix

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Introduction

Based on the perception of a need to define specific skills that graduates should possess, the SPE Talent Council conducted a study of university curricula as well as industrial expectations regarding the technical knowledge of recent graduates in petroleum engineering. A matrix of "technical knowledge sets" was created using data from numerous universities, where particular attention was placed on knowledge outcomes. These technical knowledge sets were used to create a survey that was sent to a wide variety of of companies in the E&P sector (integrated oil companies (IOC's), national oil companies, (NOC's), and service/technology providers. Companies were asked to rank each knowledge set as follows:

- "Required" (indispensible),
- "Valued" (desired, but not necessary), or
- "Not required" (not necessary or not applicable).

The long-term objective of the SPE Graduate Technical Knowledge Matrix is that this serves as a *reference* tool for industry, academia, and students. The matrix *is not meant to be definitive* with reference to curriculum criteria, entry-level hiring requirements, or student self-assessment — nor should the matrix is be seen as any component of the accreditation process for assessing university programs in Petroleum Engineering. The matrix as it exists today is simply a mechanism to gather information and to disseminate reference points for the use and benefit of industry, academia, and students.

Definitions

The following defines classification of response in the initial survey and matrix:

- *Required:* The basic knowledge that companies see as a foundation technology knowledge set for newly hired petroleum engineering graduates
- *Valued:* The technical knowledge set that, while not required of new hires, it is none-the-less valued by employers.
- "*Not Required:* The technical knowledge set that is NOT required by industry (or is not applicable) with regard newly hired petroleum engineering graduates.

Development Principles

The matrix was constructed from an exhaustive review of industrial and academic sources, as well as using input from expert-level colleagues in industry. In particular, university curricula and learning outcomes were compiled around the knowledge sets in general engineering and various technical disciplines within petroleum engineering. In addition, targeted personnel in industry were asked to provide technical knowledge sets in their area of expertise which they believe should be required, valued, or not required of new petroleum engineering graduates. SPE staff and resources were then utilized in producing the survey and tabulating the results.

Development Process

The SPE Talent Council charged a subcommittee from a diversified group of participants from industry and academia for this effort. It was recognized that the matrix would need to be a "living" document (i.e., not a static set of criteria). As such processes have been implemented to ensure continued updating, revision, and resurveying.

A survey was created and sent to 109 companies (including international and national oil companies, as well as mid-size companies and companies in the service sector). The participation rate was approximately 51 percent, which stands to validate the results in the survey.

Conclusions

The survey response to the proposed SPE Graduate Technical Knowledge Matrix suggests that the E&P sector of the petroleum industry assigns essential value to specific technical knowledge sets for petroleum engineering graduates. In particular, it is absolutely clear that graduates in petroleum engineering must have a solid foundation in breadth knowledge and engineering skill sets.

The survey responses clearly reflect a desire for graduates in petroleum engineering to have a practical knowledge of field practices and operations, as well as a working knowledge of the foundations of petroleum engineering — drilling, production, and reservoir engineering — as well as geoscience, economics, technical writing and technical presentations.

Acknowledgements The SPE expresses its appreciation to those practicing engineers who participated in the construction and evaluation of the SPE Graduate Technical Knowledge Matrix.

| 1: Knowledge Task | | | | JIRED |
|--|-------|----------------|---------------|---------------------|
| Able to apply knowledge of mathematics, science, and engineering | | 97.7% | | <mark>2.3</mark> % |
| Able to identify, formulate, and solve engineering problems | | 88.4% | | 11.6 % |
| Able to communicate effectively | | 76.7% | 23 | .3% |
| An understanding of professional & ethical responsibility | | 76.7% | 23 | .3% |
| Able to use the techniques, skills & modern engineering tools necessary for engineering practice. | | 74.4% | 18.6 | % 7% |
| Able to design & conduct experiments, as well as to analyze and interpret data | | 72.1% | 23.3 | % <mark>4.7%</mark> |
| Able to function on multidisciplinary teams | (| 6 9.8 % | 30.2 | 2% |
| Able to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health & safety, manufacturability & sustainability | 62 | 2.8% | 30.2% | 7% |
| Able to deal with high level of uncertainty in definition & solution of petroleum reservoir problems. | 60 | .5% | 34.9% | <mark>4.7%</mark> |
| A recognition of the need for & an ability to engage in life-long learning | 39.5% | | 58.1 % | <mark>2.3</mark> % |
| The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental & societal context | 37.2% | | 60.5% | <mark>2.3</mark> % |
| A knowledge of contemporary issues | 23.3% | 62.8 | 8% | 14% |

| 2: General Petroleum Engineering | | | UIRED |
|---|-------|-------|--------------|
| Calculate fluid pressure losses starting at the reservoir, following the fluid up the well and through basic production systems | 63.4% | 36.69 | % |
| Demonstrate knowledge of the effects of production rate & fluid type & how they influence friction in tubulars | 56.1% | 41.5% | 2.4 % |
| Describe the information available from hands-on tests with completion & produced fluids (density, viscosity, fluid loss control, fluid-fluid reactions, fluid-rock reactions, etc.), know why they are important & how they are used in production engineering | 56.1% | 41.5% | 2.4 % |
| Describe oil field vocabulary & familiarity with methods & materials used in producing & completing oil & gas wells | 51.2% | 43.9% | 4.9% |
| Draw/describe entire well as self contained pressure vessel under expected dynamic & static conditions at all phases of life, demonstrate how mud, brine, casing, cement, packers, tubing, wellhead & seals combine to make a pressure | 48.8% | 46.3% | 4.9% |
| Describe the systems analysis concept for optimization and backpressure techniques for monitoring well performance | 43.9% | 46.3% | 9.8% |

3: General Petroleum Engineering

| | | | | DT REQUI | RED |
|---|-------|-------|---------------|----------|-----------------------------|
| Describe and define reservoir volume | | 87.2% | | 1 | 0.3 <mark>%</mark> % |
| Calculate subsurface pressure and temperature given gradients | | 84.6% | | 10 | .3 <mark>%.</mark> 1% |
| Describe material balance concepts | | 84.6% | | 12 | 2.8% <mark>6</mark> % |
| Describe flow in porous media | | 84.6% | | 12 | 2.8% <mark>6</mark> % |
| Apply unit conversion factors | | 79.5% | | 20 | .5%0.0% |
| Describe and define types of porosity and demonstrate knowledge of how and why porosity varies | | 79.5% | | 17. | 9% <mark>2.6</mark> % |
| Describe Darcy's experiment | | 76.9% | | 20.5 | 5% 2.6 % |
| Describe the relationship between interconnected and non-interconnected porosity and permeability | | 76.9% | | 20.5 | 5% 2.<mark>6</mark>% |
| Define measured depth, true vertical depth & which is used in hydrostatic, friction & displacement calculations | | 74.4% | | 23.1 | % 2.6% |
| Describe & define hydrocarbon production rate | | 74.4% | | 25.6 | % |
| Describe & define hydraulic & lithostatic pressure gradient | | 74.4% | | 20.5% | 6 <mark>5.1%</mark> |
| Describe & define geothermal gradient | | 71.8% | | 25.6% | % 2.6 % |
| Calculate & convert equations from one system to another | | 69.2% | | 23.1% | 7.7% |
| Calculate porosity, permeability & fluid saturation given basic rock-fluid system data | | 69.2% | | 28.2% | 2.6% |
| Describe difference between horizontal & vertical permeability & what causes difference in kh & kv values | | 69.2% | | 23.1% | 7.7% |
| Calculate wellbore volume | | 66.7% | | 28.2% | <mark>5.1%</mark> |
| Describe & define formation & water resistivity | | 66.7% | | 30.8% | 2.6 % |
| Describe & define wellbore volume | | 66.7% | | 28.2% | <mark>5.1%</mark> |
| Describe & define mass density | | 64.1% | | 30.8% | <mark>5.1%</mark> |
| Describe & define fluid saturation & irreducible fluid saturation | 6 | 1.5% | | 33.3% | <mark>5.1%</mark> |
| Describe & define absolute permeability & how permeability changes with flowing & stress conditions | 59 | 9.0% | | 38.5% | <mark>2.6</mark> % |
| Describe the generalized 2-D form of Darcy's equation | 59 | 9.0% | | 38.5% | 2.6 % |
| Define kelly bushing (KB), subsea (SS) & mudline (ML) references on logs | 56 | .4% | ; | 38.5% | <mark>5.1%</mark> |
| Describe & define the wellbore environment | 56 | .4% | | 41% | <mark>2.6</mark> % |
| Explain system intensive & extensive property, & equilibrium state | 35.9% | | 53.8 % | | 10.3% |

| 4: Drilling /Completion Fluids | | | | QUIRED |
|--|----------|---------------|---------------|--------------------------|
| Know the purpose of Bentonite, Barite & common mud additives | | 77.1% | | 20% 2. <mark>9</mark> % |
| Define equivalent circulating density & know how it affects bottom hole pressures | | 68.6% | 25.7 | 7% 5.7% |
| Able to describe how changing temperature affects brine density & bottom hole pressure | 6 | 5.7% | 28.6 | % 5.7% |
| Define forward & reverse circulation & note examples of where each is used | 62 | 2.9% | 28.6% | 8.6% |
| Evaluate & specify cement systems & when light weight & heavy weight cement | 54.3 | 3% | 37.1% | 8.6% |
| systems are used Know the commonly used completion brines (weight chemical composition & crystallization point) | 54.3 | 3% | 34.3% | 11.4% |
| Able to increase or decrease the density of an existing mud system | 54.3 | 3% | 34.3% | 11.4% |
| Apply selected & use appropriate rheology model: Newtonian, Power Law & | 54.3 | 3% | 40% | 5.7% |
| Bingnam Plastic Able to measure fluid density using a mud balance and know when to specify a pressurized mud balance | 51.4 | % | 40% | 8.6% |
| Able to perform routine diagnostic tests for mud contamination | 45.7% | o | 45.7 % | 8.6% |
| Able to measure fluid viscosity using a rotary viscometer and Marsh funnel | 45.7% | o | 48.6 % | 5.7% |
| Able to use a low-pressure filter press to evaluate the wall building properties of a mud system | 42.9% | | 51.4 % | 5.7% |
| Able to measure solids content using retort | 37.1% | | 60% | <mark>2.9</mark> % |
| 5: Drilling Flow Systems | REQUIRED | | NOT RE | QUIRED |
| Ability to calculate hydrostatic pressure of a single fluid column as well as complex (dual gradient) fluid systems | | 74.3% | 2 | 2.9% 2. <mark>9</mark> % |
| Ability to calculate frictional pressures losses in pipe and annuli for Newtonian and non-Newtonian fluids | | 71.4% | 2 | B.6 % |
| Ability to plot the pressure profile in a wellbore under both static and non-static conditions | 62 | 2.9% | 34.3 | % 2.9% |
| Knowledge of shoe tests, leakoff tests and flow check tests | 57. | .1% | 37.1% | 5.7% |
| Ability to determine laminar/turbulent transition for Newtonian, Power Law and Bingham Plastic fluids | 57. | .1% | 40% | <mark>2.9</mark> % |
| Ability to calculate accelerational pressure losses through a bit nozzle or choke | 48.69 | % | 48.6 % | <mark>2.9</mark> % |
| 6: Drilling Equipment | | | NOT RE | QUIRED |
| Be able to discuss equipment used to drill a well: bit, drill collars, stabilizers, drill pipe, Kelly, standpipe, identify different types of bits | | 73.5% | 20 | .6% <mark>5.9%</mark> |
| Describe kick detection tests, shut-in procedures, routine kill methods (drillers method and weight and weigh) | 6 | 4.7% | 29.4 | % 5.9% |
| Be able to identify and define the parts of a drilling rig | 6 | 4.7% | 23.5% | 11.8% |
| Be able to identify and define drilling rig systems | 61 | l .8 % | 32.4% | 5.9% |
| Familiarity with cementing equipment and procedures (e.g., centralizers, two-plug methods, rotating and circulating heads, jet-cone mixers and pod blenders) | 58 | .8 % | 35.3% | <mark>5.9%</mark> |
| Be able to calculate the power requirements for the rigs draw works and mud pumps | 41.2% | | 47.1% | 11.8% |
| | | | | |

| COMPLETIONS | | | RED |
|---|-------|-------|-----------------|
| Be able to calculate displacement of tubular, and volumes in pipe and annular spaces | 79.4% | 17.6 | i% 2.9 % |
| Describe an open hole and a cased hole and state the advantages/ disadvantages of each | 79.4% | 17.6 | % 2.9 % |
| Describe the difference between a full string and a liner | 76.5% | 17.6% | 5.9% |
| Describe the common methods of perforating (shaped charge or "jet", abrasive perforating, mechanical, bullet, etc.) | 73.5% | 20.6% | 5.9% |
| Describe the basic tubular strings of a well (conductor, surface, production) | 73.5% | 20.6% | 5.9% |
| Describe the difference between overbalanced, balanced and underbalanced perforating and where each is used | 70.6% | 23.5% | 5.9% |
| Describe how much cement is needed in the annulus of each casing string and why possible cement column height is limited | 67.6% | 26.5% | 5.9% |
| Describe basic hydraulic fracturing stimulation and list the elements (pumps, blenders, wellhead isolation (frac tree), fluids, proppant, etc) | 64.7% | 26.5% | 8.8% |
| Ability to evaluate performance of tubular (burst, collapse, tension) | 64.7% | 32.4% | 2.9% |
| Describe the benefits or vertical, deviated, horizontal & toe-up horizontal wells & where each is most applicable in respect to fluid type, secondary/ tertiary recovery & geology | 64.7% | 32.4% | 2.9 % |
| Describe function of a wellhead & the various components (wellhead flange, master valves, crown valves, wing valves, flow-cross or flow T, annular access valves, cellars, casing & tubing hangers) including how each section | 61.8% | 38.2% | |
| Describe general knowledge of oil field tubular (connections, grades, weights, etc) | 61.8% | 32.4% | 5.9% |
| Describe the stages of a frac and what each does (pad, slurry, flush) | 58.8% | 32.4% | 8.8% |
| Describe the causes of sand movement in a weakly cemented formation (fluid drag, relative perm decrease at first water flow, high velocity, tectonic stresses, wellbore breakout, etc.) and how sand movement can be | 58.8% | 38.2% | 2.9 % |
| Describe the purposes for and the basic types of packer systems and most common equipment | 58.8% | 38.2% | 2.9% |
| Describe how the frac and well equipment must be designed to contain the frac (tubing and packer forces from temperature and pressure, cement requirements, pipe burst limits, annular monitoring, pop-off valves, pressure | 55.9% | 38.2% | 5.9% |
| Describe the types of subsurface safety valves and when they are required | 55.9% | 38.2% | 5.9% |
| Describe the purpose for a dual completion and the basic equipment used | 55.9% | 38.2% | 5.9% |
| Describe the effect of temperature changes in the trapped (unvented) annular fluids on the inner casing or tubing | 55.9% | 41.2% | 2.9 % |
| Display knowledge of fracture breakdown, fracture extension, tip screenout, wellbore screenout, ISIP, fracture flosure, wellbore friction, perf friction, etc. Demonstrate ability to find a fracture top using a temperature log | 52.9% | 41.2% | 5.9% |

7: WELL COMPLE

| tribe the common conveyance methods and where each is best used (wireline, coiled tubing, tubing conveyed) | 52.9% | 41.2% | 5.9% |
|---|-------|---------------|--------------|
| escribe how corrosion properties of produced and injected fluid affect material selection (i.e., need for 13Chrome and duplex compositions, plastic lined systems, etc.) | 52.9% | 47.1% | |
| Describe how increasing tubular string tension decreases collapse resistance | 50% | 41.2% | 8.8% |
| ribe the basic sand control methods (rate control with a choke, cavity letion, stand alone screen, gravel pack (CH and OH), high rate gravel pack and frac pack) and the advantages/disadvantages of each | 47.1% | 50% | 2.9 % |
| scribe how charge size, charge type (DP or BH), number of charges, charge phasing, entrance hole) are selected | 47.1% | 47.1% | 5.9% |
| ibe tubular string components (profiles, pup-joints, hangers, etc.) and their use | 47.1% | 44.1% | 8.8% |
| escribe causes and warning signs of sand control failure and possible repair methods | 44.1% | 55.9% | |
| onstrate how to select gravel size and sand control screen mesh size from formation particle sieve analysis | 41.2% | 52.9 % | 5.9% |
| | 41.2% | 50% | 8.8% |
| he high stress and possible failure areas in HPHT completions (seals, uate cement, corrosion, buckling of tubulars, connection cycling, etc) | 35.3% | 58.8% | 5.9% |
| escribe special equipment and fluids required for a HPHT completion | 35.3% | 58.8% | 5.9% |
| be the function of equipment used to place a sand control completion work string, crossover, gravel pack packer (multi-position), wash pipe, | 35.3% | 55.9% | 8.8% |

Desci

De casing

Descr comple

Des

Descril

Demo

Describe inadequ

Describ (w screen, gravel, etc)

| | | VALUED | | QUIRED |
|--|-------|--------|-------|-------------------|
| Calculate pressure drops in the system when circulating drilling mud | 57.6% | | 33.3% | 9.1% |
| Determine fracture gradients offshore | 51.5% | | 39.4% | 9.1% |
| Understand shallow hazards such as shallow gas and shallow water flows | 51.5% | | 39.4% | <mark>9.1%</mark> |
| Evaluate the results of seal tests | 39.4% | 42.4 | 1% | 18.2% |
| Describe dual gradient drilling | 36.4% | 54 | -5% | 9.1% |
| | | 54 | E9/ | 0.4% |
| Describe environmental forces acting on a floating drilling vesser | 36.4% | 54 | .9 % | 9:170 |
| Calculate forces and displacements in moored drilling applications | 30.3% | 54.5% | D | 15.2% |
| Determine accumulator capacity requirements in deepwater drilling | 27.3% | 60.6% | ō | 12.1% |

8: Floating Drilling

| 9: Directional Drilling | | | NOT REQUIRED |
|---|-------|-------|-----------------------|
| Understand the theory of BHA design in controlling wellbore trajectory | 48.5% | 4 | 5.5% 6.1% |
| Perform wellbore survey calculations | 45.5% | 45. | .5% <mark>9.1%</mark> |
| Understand drilling with positive displacement motors and turbines | 39.4% | 54.5 | 5% 6.1% |
| Describe methods for kicking off from vertical | 39.4% | 57. | .6% 3% |
| Calculate the effect of torque on drillstring twist | 39.4% | 54.5 | 5% 6.1% |
| Perform well planning and design for directional drilling including horizontal drilling | 39.4% | 54.5 | 5% <mark>6.1%</mark> |
| Perform calculations for performing trajectory changes in the wellbore | 36.4% | 57.6 | % 6.1% |
| Calculate torque and drag in directional wellbores | 33.3% | 60.6% | % 6.1% |

10: Describe terminology and commonly-applied methods for quantifying well performance

| | | | NO. | |
|--|-----------|-------|-----|---------------|
| Explain the relationships between porosity and permeability and how these propertie influence the flow of fluids in reservo | s ir | 84.4% | | 12. |
| Describe reservoir fluids black oils and dry gase | s | 81.3% | | 15.6 |
| Explain how to derive and apply the material balance relation for a slightly compressib liquid (oil) system and the material balance relation for a dry gas syste | le m | 71.9% | | 21.9% |
| Describe utilize the "skin factor" concept derived from steady-state flow to represe damage or stimulation (including the apparent wellbore radius conception) | nt ot) | 68.8% | | 28.1 % |
| Sketch a plot of pressure versus logarithm of radius and identify all major flow regime (i.e., transient, pseudosteady-state, and steady-state flow behavio | s r) | 62.5% | | 34.4% |
| Application - familiar with the diffusivity equations for liquids and gases, and aware of th assumptions, limitations, and applications of these relation | e s | 56.3% | 4 | 0.6% |
| Apply the pseudosteady-state flow equation for a liquid (black oil) system | n t | 56.3% | 4 | 0.6% |
| Derive and apply the steady-state flow equations for horizontal linear and radial flows on liquids and gases, including the pseudopressure and pressure-squared form | of s 5 | 3.1% | 37. | 5% |
| Explain the use of dimensionless variables and dimensionless solutions to illustrate th generic performance of a particular reservoir mod | el 43.8 | 3% | 50% | |

11: Apply Well Test Analysis using Conventional Plots



NOT REQUIRED

REQUIRED

Construct and interpret a plot of pressure versus time to establish the parameters related to wellbore storage behavior (i.e., the "early time" plot)

Construct and interpret a plot of the logarithm of pressure drop and pressure drop derivative versus the logarithm of time to establish the parameters related to wellbore storage, radial flow, and vertical fracture behavior (i.e., the "log-log" plot)

Construct and interpret a plot of pressure versus the logarithm of time to establish the parameters related to radial flow behavior (i.e., the "semilog" plot)

12: Apply Well Test Analysis using Type Curve Analysis REQUIRED NOT REQUIRED

| 50% | 43.3% | 6.7% |
|-------|-------|------|
| | | |
| 50% | 43.3% | 6.7% |
| | | |
| 46.7% | 50% | 3.3% |
| 46.7% | 50% | 3.3% |

Use type curves to analyze well test data where the data include effects from closed boundaries or sealing faults

Use a type curve to analyze well test data from an unfractured well which includes wellbore storage distortion and radial flow behavior (including damage or stimulation (i.e., skin effects)

Use a type curve to analyze well test data from a fractured well which includes wellbore storage, distortion, fracture flow regimes, and radial flow behavior

| 1 | | | | REQUI | RED | |
|--------|---|-------|-----|-------|--------------|---|
| 5 | | 76.7% | | 20% | 3. 3% | 6 |
| | | | | | | |
| h h | 6 | 0% | 30% |) | 10% | |

13: Apply Production Data Analysis

Estimate the "recoverable reserves" for an oil or gas well using plots of rate versus time (semilog rate format) and rate versus cumulative production

Use decline type curves to analyze production data from an unfractured or hydraulically fractured oil of gas well - where these type curves illustrate both transient and boundary dominated flow behavior

| - | | |
|--|-------|-------------------------|
| Apply net present value, rate of return, and pay back period | 86.7% | 10%-3% |
| Apply discount cash flow | 83.3% | 13.3% <mark>.</mark> 3% |
| Apply cash flow | 83.3% | 13.3%-3% |
| Understand elementary of petroleum reserves accounting | 76.7% | 20% 3 <mark>.3</mark> % |
| Apply reserves definitions | 66.7% | 30% <mark>3.3</mark> % |
| Apply probabilistic approach | 56.7% | 36.7% 6.7% |

14: Understand and use Basic Project Economic

15: Derive and use the Gas Material Balance coupled with Forecasting

| ∎ RI | EQUIRED | | | REQUIRE | D |
|--|---------|-------|---|---------------|--------------|
| Describe gas material balance | | 76.7% | | 23. | 3% |
| Describe steady state water drive | | 66.7% | | 26.7 % | 6.7% |
| Define and evaluate water drive with forecasting | | 66.7% | | 26.7 % | 6. 7% |
| Describe unsteady state water drive | Ę | 56.7% | 3 | 33.3% | 10% |
| Combine material balance with IPR's for production forecasts | Ę | 56.7% | | 36.7% | 6. 7% |

16: Derive and use the Oil Material Balance coupled with Forecasting

| | | NOT REQU | IRED |
|--|-------|---------------|------|
| Describe volumetric and non-volumetric reservoirs | 63.3% | 30% | 6.7% |
| Describe black oil material balance | 60.0% | 33.3% | 6.7% |
| Derive and use the black oil material balance for saturated reservoirs | 56.7% | 36.7% | 6.7% |
| Describe combining material balance with IPR's for production forecasts | 53.3% | 40% | 6.7% |
| Describe and evaluate drive indexes | 53.3% | 36.7% | 10% |
| Derive and use a general black oil material balance with gas injection and water drive | 46.7% | 46.7 % | 6.7% |

17: Derive and Describe Immiscible Frontal Advance Theory and Applications

| | | D NOT REQUIR | ED |
|--|-------|-----------------|------|
| Explain mobility ratios and factors that affect displacement efficiency | 56.7% | 36.7% | 6.7% |
| Evaluate waterflooding models for homogeneous and heterogeneous reservoirs | 53.3% | 43.3% | 3.3% |
| Describe Use Styles Method | 43.3% | 46.7% 1 | 10% |
| Use Dykstra-Parsons Method | 43.3% | 46.7 % 1 | 0% |

| | | NO | T REQUIRED |
|--------------------------|-------|----|---------------|
| , on a pleum neers | 73.3% | | 26.7 % |

6.7%

36.7%

NOT REQUIRED

3.3%

10%

50%

46.7%

53.3%

18: Multidisciplinary Team Skills

Work effectively, as measured by peer and instructor evaluations. multidisciplinary team consisting of geophysicists, geologist, and petro enai

19: Explain how to conduct an Integrated Reservoir Study, including the components of a study and data required **REQUIRED**

| List the data required for a reservoir simulation study | 4 |
|--|---|
| List and explain the phases of an integrated reservoir study | 4 |

Explain common terminology, objectives, methods and results associated with each

of the disciplines involved in an integrated reservoir study

20: Develop a complete description of a Hydrocarbon Reservoir using geoscientific engineering methods

| | | D NOT RE | QUIRED |
|-------|---|----------|--------|
| 43.3% | | 43.3% | 13.3% |
| 36.7% | | 60% | 3.3% |
| 33.3% | | 60% | 6.7% |
| 30% | | 60% | 10% |
| 26.7% | | 60% | 13.3% |
| 26.7% | 5 | 6.7% | 16.7% |

Lead a multidisciplinary team in engineering evaluations of pressure, production, PVT and SCAL data to determine reservoir and well properties

As a member of a multidisciplinary team, assist in a geological evaluation resulting in the creation of structural and stratigraphic cross sections and contour maps of geological and petrophysical properties such as structure, reservoir thickness and

As a member of a multidisciplinary team, assist in a geophysical evaluation resulting in the interpretation of structure and faulting in a typical hydrocarbon reservoir

As a member of a multidisciplinary team, develop correlations of seismic an petrophysical data and extrapolate petrophysical properties using the seismic data

Lead a multidisciplinary team in a petrophysical evaluation of core data and openhole log data using modern petrophysical evaluation software

21: Given a complete reservoir description and well data, and design, construct, execute and quality check a reservoir simulation model

| | | | NOT REQ | UIRED |
|---|-------|---|---------|-------|
| on model and verify the accuracy of the production data input to the model | 41.4% | | 51.7% | 6.9% |
| model and verify the reasonableness and accuracy alculated initial pressure and saturation distributions | 41.4% | | 51.7% | 6.9% |
| eservoir description and well data, create a data set voir simulator to model performance of the reservoir | 41.4% | | 51.7% | 6.9% |
| ervoir simulation history match, including objectives, ched, match criteria, and a prioritized list of well and | 34.5% | 5 | 1.7% | 13.8% |
| reservoir description data to be varied in the match n model to observed performance data by modifying reservoir description data within reasonable limits. | 27.6% | 6 | 5.5% | 6.9% |

Execute the reservoir simulati

Initialize the reservoir simulation of the ca

From a complete, integrated re for a commercial reser

Develop a plan for a rese performance data to be mate

Calibrate a reservoir simulation

22: Predict and optimize reservoir performance using reservoir simulation and economic modeling



NOT REQUIRED

Predict future performance of a reservoir using reservoir simulation, given specifications (in typical field terms) as to how the reservoir is to be operated Determine the optimum development plan for a reservoir, using reservoir simulation and economic modeling, by minimizing or maximizing an appropriate

23: Effectively communicate the results of an integrated reservoir study orally and in written reports

| Effectively present the results of an integrated reservoir study in a written report | 58.6% | 37.9% | 3. <mark>4</mark> % |
|--|-------|---------------|---------------------|
| | | | |
| Effectively present the results of an integrated reservoir study orally | 55.2% | 41.4 % | 3. <mark>4</mark> % |

24: Describe and calculate basic properties of the rock fluid system affecting the storage and flow capacity of the system and distribution of fluids with the system

| | | | IRED |
|---|-------|-------|-----------------------|
| Define porosity, rock compressibility, fluid saturation, boundary tension, wetability, capillary pressure resistivity, resistivity factor, resistivity index, saturation exponent, and cementation factor | 86.2% | 1 | 0.3 <mark>%4</mark> % |
| Use them in typical reservoir engineering calculations | 75.9% | 17.29 | % 6.9% |
| Discuss factors that affect them | 72.4% | 24.19 | % 3 <mark>.4%</mark> |
| Discuss inter-relationships among them | 69% | 27.6% | . 3 <mark>.4</mark> % |

| 25: Calculate permeability using Darcy's Law | | NOT REQUIRED |
|--|-------|---------------------------|
| Discuss Darcy's experiment | 79.3% | 17.2%3.4% |
| Darcy equation and explain its meaning | 65.5% | 31% 3 <mark>.4</mark> % |
| Integrate the Darcy equation for typical reservoir rock fluid systems | 58.6% | 37.9% 3 <mark>.4</mark> % |
| Reproduce the differential form of the | 55.2% | 41.4% 3.4% |
| Calculate the permeability of flow units in parallel and in series and with fracture channels | 51.7% | 44.8% 3.4% |

26: Describe and use effective and relative permeability

| | | | | UIRED |
|---|----|---------------|-------|-------------------------|
| Define effective permeability and relative permeability | | 82.8 % | | 13.8% <mark>.4</mark> % |
| Reproduce typical relative permeability curves and show effect of saturation history on relative permeability | | 62.1% | 34.5% | % 3 <mark>.4</mark> % |
| Use relative permeability data in typical reservoir engineering applications | 5 | 8.6% | 37.9% | 3 <mark>.4</mark> % |
| Use correlations to estimate relative permeability | 55 | 5.2% | 41.4% | <mark>3.4</mark> % |

27: Describe and use 3-phase relative permeability

| | REQUIRED | | NOT REQU | JIRED |
|---|----------|---|----------|-------|
| Describe 3-phase flow in reservoir rock | 55.2% | | 37.9% | 6.9% |
| | | | | |
| Use correlations to estimate 3-phase relative permeability | 41.4% | | 51.7% | 6.9% |
| Use ternary diagrams to display 3-phase relative permeability | 27.6% | e | 5.5% | 6.9% |
| | | | | |

28: Design and conduct experiments to determine basic rock fluid properties

| rties | | | NOT REQU | IRED |
|--|-------|---|----------|-------|
| Analyze and interpret experimental data | 58.6 | % | 31% | 10.3% |
| Prepare laboratory reports | 48.3% | | 37.9% | 13.8% |
| Design and conduct experiments to determine porosity, rock compressibility, absolute and relative permeability, fluid saturation, capillary pressure, and electrical properties of reservoir rocks | 37.9% | 5 | 51.7% | 10.3% |

29: Able to interpret common open hole logging measurements for lithology, porosity, and water saturation estimates and their associated uncertainties

| | | | UIRED |
|--|-------|---------------|-----------------------|
| Estimate water resistivity and saturation with a Pickett plot | 65.5% | 31% | |
| Estimate saturation using Archie's laws in clean formations | 62.1% | 34.5% | . 3 <mark>.4</mark> % |
| Estimate porosity in shaly sands | 58.6% | 34.5% | 6.9% |
| Estimate porosity in the Monomineral case | 55.2% | 31% | 13.8% |
| Describe Clay types, geometries, and effects on formation properties | 51.7% | 41.4% | 6.9% |
| Estimate saturation using double-layer and V-shale models in shaly | 41.4% | 48.3% | 10.3% |
| Estimate water resistivity, matrix density/transit time, and saturation with a Hingle plot | 41.4% | 48.3% | 10.3% |
| Estimate porosity and lithology in Binary Mixture case | 41.4% | 41.4% | 17.2% |
| Estimate lithology in Ternary Mixtures case | 31% | 55.2 % | 13.8% |

30: Able to perform basic wireline log evaluations on a commercial software package

| ware package | | REQUIRED | | | IRED |
|--------------|--|----------|---|-------|--------------|
| | Display and interpret data | 51.7% | 6 | 44.8% | 3.4 % |
| | Display log data and results on analyses | 51.7% | 6 | 44.8% | 3.4 % |

31: Able to integrate wireline logging data with basic core data in order to assess formation lithology porosity, and permeability

| | EQUIRED | | | IRED |
|---|---------|------|---------------|--------------------|
| List benefits and problems of integrating log and core data | 5 | 8.6% | 34.5% | 6.9% |
| Depth matching of core and log data | 51. | .7% | 44.8 % | <mark>3.4</mark> % |

32: Understand various types and forms of reservoir heterogeneity and its role in reservoir performance. Appreciate the uncertainty in reservoir property estimates and the need to quantify it. Understand the difference between deterministic vs. stochast

| | | | NOT REQUI | RED |
|---|------|------|-----------|------|
| Describe estimation and uncertainty | 6 | 5.5% | 31% | 3.4% |
| Describe the use of statistics in petroleum engineering | 55.2 | 2% | 41.4% | 3.4% |

34: Learn about statistical moment and expectations and how to formulate various estimators using these concepts. Learn about estimator bias, efficiency and robustness. Learn about confidence intervals an apply the concept to permeability estimates REQUIRED VALUED

| I | | |
|----------|--|---|
| 51.7% | 34.5% | 13.8% |
| | | |
| 48.3% | 34.5% | 17.2% |
| | | |
| 37.9% | 44.8 % | 17.2% |
| 07.00/ | E4 30/ | 10.00/ |
| 37.9% | 51.7% | 10.3% |
| 31 5% | /19 2% | E0 /. |
| J-1:3 /0 | 40.J /0 | |
| 27.6% | 58.6% | 13.8% |
| | 51.7% 48.3% 37.9% 37.9% 34.5% 27.6% | 51.7% 34.5% 48.3% 34.5% 37.9% 44.8% 37.9% 51.7% 34.5% 48.3% 27.6% 58.6% |

NOT REQUIRED

35: Perform exploratory data analysis through transformations and correlation. Learn about coefficient of determination and residual analysis. Use existing software to analyze well log and core data from oil field

| | | | NOT REQUIRED |
|---|--------|----------------|--------------|
| Describe related petroleum engineering applications | 31% | 41.4% | 27.6% |
| Describe residuel englysis | 27 60/ | AA 90/ | 37 69/ |
| | 21.0% | 44.0 /0 | 21.07 |
| Describe joint distribution | 27.6% | 48.3 % | 24.1% |
| Describe coefficient of determination | 24.1% | 48.3% | 27.6% |

36: Learn about analysis of spatial data using variograms and variogram modeling, rules and physical significance of variogram modeling. Practical applications using the software GEOEAS

| | | | NOT REQUIRED |
|--------------------------------|-------|---------------|--------------|
| Describe rules and assumptions | 31% | 41.4 % | 27.6% |
| Describe variograms | 31% | 41.4 % | 27.6% |
| Describe variogram modeling | 27.6% | 44.8 % | 27.6% |
| Describe semivariance | 24.1% | 51.7% | 24.1% |

37: Learn about spatial modeling or reservoir properties using kriging and the use of kriging variance as a measure of uncertainty, basic concepts of conditional simulation and the need to study multiple realizations. Solve examples using GEOEAS

| | | VALUED | NOT REQUIRED |
|--|-------|---------------|--------------|
| Apply uncertainty quantification | 31% | 44.8 % | 24.1% |
| | | | |
| Apply basics of conditional simulation | 27.6% | 51.7% | 20.7% |

38: Able to categorize petroleum reserves and to estimate proved reserves using volumetric and decline curve methods; also, be able to forecast future production rates vs. time

| | | | | REQUI | RED |
|--|----|------|---|-------|--------------|
| Able to forecast future production rates vs. time using decline curve methods | 6 | 5.5% | | 31% | 3.4 % |
| Able to estimate reserves using volumetric and decline curve methods, and be able to identify sources of uncertainty in these calculations | 62 | 2.1% | 3 | 4.5% | 3.4 % |
| Able to summarize reserve categories as defined by the SPE | 62 | 2.1% | 3 | 4.5% | 3.4 % |

39: Able to state in concise summary form, the fundamental forms of ownership of petroleum resources, and laws, fiscal systems and financial interests pertinent to their exploitation internationally

| | | | NOT REQU | JIRED |
|---|-------|---|---------------|-------|
| Able to compute expenses and revenue interest in petroleum properties | 41.4% | | 48.3% | 10.3% |
| Able to summarize petroleum lease laws and categories of ownership of mineral interest | 37.9% | | 48.3% | 13.8% |
| Able to summarize the types of ownership interests and fiscal systems present in various producing nations and the potential impact of these systems on engineering | 34.5% | 5 | j1.7 % | 13.8% |
| project economics | | | | |

40: Able to perform basic cash flow analysis for petroleum projects and to determine whether proposed projects are acceptable or unacceptable and, in a given list of acceptable projects, determine which projects are most

| attractive | | | |
|--|---|-------|-------------------------|
| Explain the concepts of interest, present value, future value and time value of money | | 86.2% | <mark>10.3%4</mark> % |
| Able to construct a cash flow stream for a petroleum project, including calculation of taxes | | 79.3% | 13.8% <mark>6.9%</mark> |
| Able to determine the most attractive projects from a group of acceptable projects using investment yardsticks | , | 75.9% | 17.2% <mark>6.9%</mark> |
| Able to determine whether a given project is acceptable or not, using investment yardsticks | | 65.5% | 27.6% 6.9% |
| Able to calculate investment yardsticks for petroleum investment projects, including those based on time-value-of-money concepts and those based on other considerations | | 65.5% | 27.6% 6.9% |

41: Able to evaluate uncertainty in reserve estimates and economic appraisal

| appraisal | | | | IRED |
|--|-------|----|-------|--------------------|
| Able to perform sensitivity analyses and risk adjustment calculations and to recognize and/or minimize the risk inherent in a project | 60.7 | 7% | 35.7% | 3.6% |
| Able to apply basic probability theory to evaluate uncertainty in petroleum projects | 60.7 | 7% | 35.7% | <mark>3.6</mark> % |
| Able to describe strengths, weaknesses, and limitations of Monte Carlo analysis and to describe broadly how this technique is applied to petroleum projects | 46.4% | | 46.4% | 7.1% |

42: Able to set personal career and financial goals, including personal investment, planning, financial management, and a life-long learning plan

| | | | REQUIRED |
|--|-------|-------|----------|
| Able to set personal career goals | 64.3% | 25 | % 10.7% |
| | | | |
| Establish a life-long learning plan consistent with career goal | 42.9% | 39.3% | 17.9% |
| Able to set personal financial goals and establish a plan to reach those goals | 39.3% | 35.7% | 25% |
| | | | |

NOT REQUIRED

43: Able to incorporate social, political, cultural, and environmental factors into decision making

44:

| Able to incorporate social, political, cultural, and environmental factors into decision making | 46.4% | <u> </u> | 50% | 3.6% |
|---|------------------|---------------|------------|-----------|
| Production Operations | REQUIRED | ■VALUED ■N | 10T REQUIR | ED |
| Basic understanding of measurement of produced fluids and gas | 7 | 76.9 % | 23.1 | % |
| Describe common damage mechanisms (fill, emulsions, scale, paraffing, asphaltenes, hydrates, etc.), what causes the damage and how to prevent and remove the damage | 73 | 3.1% | 19.2% | 7.7% |
| Describe gas and water coning principles, control methods and calculation methods | 69 | .2% | 30.8% | |
| Describe the flow regimes for a well in natural flow | 69 | .2% | 30.8% | |
| Describe basic wireline equipment, tools and methods where wireline work assists production operations | 65. | 4% | 26.9% | 7.7% |
| Describe the basic surface facility equipment including FWKO, horizontal and vertical separators, heater treaters, electrostatic separators, vapor collection, compression, LACT units, etc | 65. [,] | 4% | 34.6% | |
| Describe where secondary recovery methods are most applicable | 64 | % | 28% | 8% |
| Describe & identify basics of scale and corrosion issues and basic remediation | 61.5 | % | 30.8% | 7.7% |

| be coiled tubing equipment tools and methods where CT work assists production operations 61.5% | 34.6% 3.8 % |
|---|---------------------------|
| proficiency in establishing a descline curve from production data and selecting the proper exponents 61.5% | 38.5% |
| ibe how an ESP works and what factors control its use and reliability 61.5% | 38.5% |
| Describe comman kift systems and their advantages/disadvantages 61.5% | 38.5% |
| be, identify & recommend surface production equipment,(separators, compression, dehy's, etc) 57.7% | 34.6% 7.7% |
| Describe methods for killing a well and bringing it back to production 57.7% | 34.6% 7.7% |
| escribe how plunger lift works and at what conditions it best operates 57.7% | 26.9% 15.4% |
| he common production corrosion mechanisms (CO2, bacterial, SSC, c, Erosion-Corrosion, etc.) and basic approaches for corrosion control | 36% 8% |
| Basic understanding of project data collection and archiving 53.8% | 30.8% 15.4% |
| Describe & recommend basic waterflood project 53.8% | 34.6% 11.5% |
| luate & recommend basic well hydraulic fracturing stimulation theory 53.8% | 42.3% 3 <mark>.</mark> 8% |
| workovers using simple economic analysis (NPV, PV10 hurdles, etc) 53.8% | 46.2% |
| Describe logging or other anaylsis methods to find skipped pay 53.8% | 42.3% 3 <mark>.</mark> 8% |
| w a gas lift well unloads and show proficiency in basic gas lift design 53.8% | 38.5% 7.7% |
| how the wellhead choke works and how it can be used to maximize natural flow liquid lift 53.8% | 46.2% |
| completion methods, equipment and design checks required to refit a naturally flowing well for gas lift 52% | 36% 12% |
| ng of field development planning (i.e. rig scheduling, Land (ROW and drilling title), etc.) 50% | 38.5% 11.5% |
| Describe, identify & recommend wellhead equipment 50% | 38.5% 11.5% |
| valuate, design & troubleshoot basic artificial lift methods (pump, gas lift, plunger lift, etc) 50% | 50% |
| neral well repair methods including cutting tubing, fishing, tubing leak repair tubing corrosion repair etc. 50% | 50% |

| Describe cased hole logs to assist in defining production points | 50% | 42.3% | 7.7% |
|--|-------|---------------|--------------------|
| Describe how a rod lift pump works, the actions of the standing and traveling valve, what causes gas lock and rod pound , and what factors help set pump stroke length and speed | 48% | 40% | 12% |
| Evaluate a field financial performance using industry used metrics (LOE statements, etc) | 46.2% | 53.8 % | |
| Demonstrate proficiency in plug and abandonment by completing a basic P&A design with required tests/monitoring identified to meet standards for a selected government regulation | 46.2% | 46.2 % | 7.7% |
| Demonstrate proficiency in well workover candidate selection by ranking candidates by skin-removal calculations, economic comparison of job costs and risk ranking to construct a ranked candidate list with expected pay-out or ROI | 46.2% | 53.8% | |
| Describe methods and equipment for spotting plugs, including sand plugs, cement plugs, retrievable and drillable plugs | 46.2% | 42.3% | 11.5% |
| Describe basic water control analysis methods and treating methods | 46.2% | 50% | 3.8% |
| Describe, identify & recommend basic completion fluids and oilfield brines | 42.3% | 46.2 % | 11.5% |
| Ability to evaluate & troubleshoot well performance using production plots | 42.3% | 53.8 % | <mark>3.8</mark> % |
| Describe unloading methods including displacement, rocking and stop-cocking | 42.3% | 46.2 % | 11.5% |
| Demonstrate how to spot liquid loading and slugging in a gas well | 42.3% | 53.8 % | 3.8% |
| Describe why fluid level shots are important and how they are done | 42.3% | 50% | 7.7% |
| Describe logging or other analysis methods to find: flow behind pipe, leaks, uncemented channels, corrosion problems, etc | 38.5% | 53.8 % | 7.7% |
| Demonstrate from production history curves and field maps which wells should be examined for workovers | 38.5% | 61.5% | |
| Describe the flow regime differences between vertical well (hindered settling) and deviated wells (fluid segregation and boycott settling) and how this affects production as production rate falls | 38.5% | 61.5 % | |
| Describe what reservoir and completions assistance is needed to initiate a secondary recovery operation | 36% | 56% | 8% |
| Understand applications and limitations of tools utilized with coiled tubing | 34.6% | 53.8 % | 11.5% |
| Describe & recommend basic acid treatments | 34.6% | 53.8 % | 11.5% |
| Describe & identify completion tools (plugs, permanent vs retrievable packers, etc) | 34.6% | 53.8% | 11.5% |

| Describe & identify basic downhole fishing tools and uses | 34.6% | 46.2 % | 19.2% |
|---|-------|---------------|--------------------|
| Display proficiency in produced water and frac backflow fluid management by constructing a basic design for handling the produced water including separating, processing, recycling or disposal | 34.6% | 61.5% | <mark>3.8</mark> % |
| Understand Turner's et al gas well loading equations application and limitations | 30.8% | 46.2% | 23.1% |
| Ability to design & evaluate saltwater disposal solutions | 30.8% | 61.5% | 7.7% |
| Describe methods for pulling and/or milling packers | 30.8% | 57.7% | 11.5% |
| Read a dynamometer card and identify the actions occuring in the recording | 30.8% | 61.5% | 7.7% |
| Exposure to crisis management. (dealing with the public, regulatory agencies and he press since the Production/Operations engineer is in the field and on the front line during a crisis) | 26.9% | 50% | 23.1% |