CAREERS THROUGH MATHS: PETROLEUM ENGINEER

JOB DESCRIPTION

Petroleum Engineers are responsible for designing and developing methods for extracting oil and gas from deposits beneath the earth's surface. In the UK context, this work is predominantly focused on maximising recovery from mature fields in the North Sea, a technically challenging and capital-intensive environment. A typical day might involve analysing well data from platforms operated by companies like Harbour Energy or Shell UK, creating computer models to simulate reservoir behaviour, and planning the trajectory for a new well to access previously untapped reserves. Their work is crucial for ensuring the UK's energy security and managing the transition towards net-zero, often involving projects that integrate carbon capture and storage (CCS) into former oil and gas fields.

The work environment is split between office-based roles, often in energy hubs like Aberdeen or London, and offshore rotations on production platforms or drilling rigs. An offshore Petroleum Engineer, for instance, could be supervising a well stimulation operation on a BP installation in the Central North Sea, ensuring that high-pressure fluids are pumped accurately into the reservoir to enhance flow. Office-based engineers spend their time using sophisticated software to interpret seismic data, calculate reserves, and model fluid flow through porous rock, making key decisions that impact multi-million-pound investments.

Mathematics is the foundation of every aspect of this role. From the initial assessment of a potential reservoir's volume to the complex optimisation of production over a field's 20-30 year lifespan, engineers rely on advanced mathematical principles to reduce uncertainty and improve efficiency. For example, they use calculus to model the rate of pressure decline in a reservoir and algebra to balance flow rates from multiple wells to ensure stable production. This mathematical rigour is essential for operating safely and profitably in the demanding conditions of the UK Continental Shelf (UKCS).

HOW MATHEMATICS IS USED

- **Calculus (Differential Equations):** This is fundamental for modelling dynamic subsurface processes. Petroleum engineers use differential equations to describe how fluids (oil, gas, water) move through the porous rock of a reservoir over time. For example, they solve the "Diffusivity Equation" to predict how pressure changes will propagate through a reservoir when a well starts producing. This helps in forecasting production rates for a new well in the West of Shetland region or managing reservoir pressure by injecting water or gas to maintain output from a mature field in the Southern North Sea.

- **Linear Algebra & Numerical Methods:** Real-world reservoirs are too complex for simple analytical solutions. Engineers discretise the reservoir into thousands or millions of grid blocks and use linear algebra to solve systems of equations that represent flow in each block. This numerical simulation, performed with software like Schlumberger's INTERSECT, is vital for history matching—comparing simulation results to actual production data from a BP or TotalEnergies field to refine the model and improve future predictions, a key task for maximising recovery.

- **Probability and Statistics:** There is significant uncertainty in subsurface data. Engineers use statistical methods and probabilistic modelling to quantify risks. For instance, when estimating reserves for a new discovery, they don't provide a single figure but a range (e.g., P90, P50, P10) using Monte Carlo simulation. This informs investment decisions by companies like Ithaca Energy, indicating a 90%, 50%, or 10% probability of exceeding a certain volume. Statistics are also used to analyse production decline trends and forecast a well's economic life.

- **Fluid Mechanics:** The mathematical principles governing fluid flow are applied to design the entire production system. This includes using the Navier-Stokes equations to model flow in pipelines transporting oil from the Mariner field to shore, or applying Bernoulli's principle to understand pressure drops through chokes and valves on an offshore platform, ensuring equipment is sized correctly and flow is controlled safely.

- **Geomechanics:** Mathematics is used to understand the mechanical behaviour of rocks. Engineers calculate stress and strain fields around a wellbore to prevent collapse during drilling or production. For example, they must mathematically determine the optimal pressure for the drilling mud to counterbalance formation pressures without fracturing the rock, a critical safety calculation for operations in the challenging high-pressure/high-temperature (HP/HT) reservoirs of the Central North Sea.

KEY SKILLS & TOOLS

Skill/Tool	Application
Reservoir Simulation Software (e.g., Schlumberger's ECLIPSE, Emerson's Roxar)	These are the primary tools for modelling reservoir behaviour. Engineers use them to solve complex systems of partial differential equations numerically. For example, they might use ECLIPSE to model the impact of injecting CO_2 into the depleted Goldeneye field for carbon storage, simulating how the CO_2 will plume over decades.
Data Analysis & Visualisation (e.g., Python with Pandas/ Matplotlib, Spotfire)	Python is extensively used for automating data analysis, such as processing daily production data from dozens of wells to identify underperforming assets. Libraries like Pandas are used to clean and aggregate data, while Matplotlib creates plots to visualise decline curves or pressure build-up tests for senior management.
Well Planning & Design Software (e.g., Landmark's COMPASS, Schlumberger's PETREL)	These tools rely on 3D vector calculus and geometry to plan well trajectories. Engineers calculate the precise azimuth, inclination, and dog-leg severity to navigate from a platform to a small reservoir target several kilometres away, avoiding other wells and geological faults.
	OLGA uses advanced fluid dynamics equations to simulate the flow of oil, gas, and water together in pipelines. This is

Production Modelling Tools (e.g., OLGA for multiphase flow)	crucial for designing the tie-back of a new subsea well to an existing platform, ensuring fluids can be transported without problems like slugging that can damage equipment.
Economic Modelling & Decision Analysis	Engineers use discounted cash flow (DCF) analysis and net present value (NPV) calculations to evaluate the economic viability of projects. They build models that incorporate capital expenditure (CAPEX), operating expenditure (OPEX), oil price forecasts, and tax regimes (like the UK's Energy Profits Levy) to recommend whether a project should be sanctioned.

Typical Pathway: The standard route begins with strong GCSEs and A-levels in Mathematics and Physics, often followed by a Master of Engineering (MEng) degree in Petroleum Engineering accredited by the Institution of Mechanical Engineers (IMechE) or the Energy Institute (EI) from a university such as Heriot-Watt, Imperial College London, or the University of Aberdeen. Graduates typically join an operator (e.g., Harbour Energy, Shell) or a service company (e.g., Schlumberger, Baker Hughes) on a graduate scheme, often involving offshore placements. With 4-5 years of experience, engineers can work towards becoming a Chartered Engineer (CEng) through the IMechE or EI, which is highly valued and accelerates career progression to senior roles like Senior Reservoir Engineer or Operations Manager. Continuous professional development (CPD) is essential, particularly with the industry's shift towards energy transition technologies.

Industry Demand: The UK oil and gas industry is mature, with demand centred on experienced engineers who can extend the life of existing fields and manage complex decommissioning projects. However, there is a growing demand for petroleum engineering skills in emerging areas such as carbon capture and storage (CCS), hydrogen storage, and geothermal energy. The North Sea Transition Authority (NSTA) emphasises maximising economic recovery, which requires sophisticated mathematical modelling, ensuring a steady need for technically skilled engineers. The job market is competitive, with a premium placed on strong numerical and analytical abilities.

Real-World Impact: Petroleum Engineers have been central to the UK's energy economy for decades, ensuring the safe and efficient production of the oil and gas that heats homes and powers industry. Their work on major projects like the Clair Ridge development west of Shetland, one of the largest hydrocarbon resources in the UK, involves complex mathematical modelling to recover resources that were previously uneconomical. Furthermore, their expertise is now critical for the UK's net-zero ambitions, as they apply their subsurface knowledge to repurpose oil and gas infrastructure for CCS projects, such as the Acorn Project in Scotland, directly contributing to the reduction of national carbon emissions.