

Introduction to Drilling Engineering

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Key concepts, terminology, and workflow for designing and executing a well?bore.

1. What Is Drilling Engineering?

Aspect	Description
Definition	Discipline that plans, designs, and oversees the creation of boreholes (wells) to access subsurface formations for oil, gas, geothermal, water, or mineral resources.
Primary Goals	• Reach target depth safely and economically • Maintain wellbore stability • Control formation pressures • Minimize non?productive time (NPT)
Stakeholders	Drilling engineers, reservoir engineers, geologists, completion engineers, HSE personnel, rig crews, service companies, owners/operators.

2. Core Elements of a Drilling Program

1. Well Planning

- **Objective definition** – production, appraisal, injection, or exploration.
- **Target selection** – depth, TVD, reservoir zone, expected pressure/temperature.
- **Feasibility study** – cost?benefit, risk assessment, regulatory compliance.

2. Well Design

- **Casing & Tubing design** – size, grade, weight?on?bit (WOB) limits, burst/ collapse ratings.
- **Wellbore trajectory** – vertical, deviated, horizontal; measured?depth (MD) vs true?vertical?depth (TVD).
- **Mud program** – type (water?based, oil?based, synthetic), density, rheology, additives.
- **Drill?string layout** – drill pipe, heavy?weight drill pipe (HWDP), drill collars, stabilizers, bit.

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3. Equipment Selection

- **Rig type** – land, offshore jackup, semi-submersible, drillship, platform.
- **Topdrive vs rotary table, blowout preventer (BOP) configuration, pump system** (triplex, duplex, triplex).

4. Operational Procedures

- **Drilling sequence** – spudding, drilling, tripping, casing, cementing, logging.
- **Safety & HSE** – BOP test, well control drills, permit-to-drill, emergency response.

5. Cost & Schedule Management

- **Daily rates, service contracts, contingency planning, performance monitoring** (e.g., ROP, NPT).

3. Fundamental Drilling Mechanics

Phenomenon	Governing Principle	Practical Impact
Weight on Bit (WOB)	Mechanical force transmitted from the drill string to the bit.	Controls penetration rate (ROP); excessive WOB → bit damage or stuck pipe.
Torque	Rotational force needed to turn the bit.	Influences bit wear, drill string torsional stress.
Rate of Penetration (ROP)	$ROP = f(WOB, RPM, \text{bit type, formation hardness, mud properties})$	Primary productivity metric; optimized by adjusting WOB, RPM, mud.
Hydraulic Horsepower (HHP)	$HHP = (\Delta P \times Q) / 1714$ (psi·gpm → hp).	Determines pump size; high HHP → higher wear, risk of surge.
Cuttings Transport	Depends on mud flow velocity, cuttings size, and density.	Prevents hole cleaning problems and stuck pipe.
Wellbore Stability	Balance of formation stresses, pore pressure, mud pressure ($\Delta P = \text{mud weight} - \text{formation pressure}$).	