Course Type	Course Code	Name of Course	L	T	P	Credit
DE	NGLD513	Geologic Carbon Storage and Enhanced Hydrocarbon Recovery	3	0	0	3

Course Objective

- Introduce geological carbon storage and enhanced hydrocarbon recovery in subsurface reservoirs.
- Understand SC-CO_2 injection, fluid–rock interaction, and storage integrity in low-permeability systems.
- Evaluate pore-scale storage physics, transport behavior, and competitive sorption processes.
- Apply advanced characterization techniques for reservoir and pore-network analysis.
- Assess coupled sequestration–recovery dynamics in adsorption-dominated reservoir systems.

Learning Outcomes

- Understand geological carbon storage, SC-CO_2 injection behavior, and storage integrity in subsurface reservoir systems.
- Analyze pore-scale storage physics, transport behavior, and competitive sorption processes in low-permeability reservoirs.
- Apply advanced reservoir characterization techniques to evaluate coupled sequestration–recovery processes.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Carbon Management & Geological Carbon Storage:** Fundamentals of climate change and carbon budget; CCUS concepts; Geological reservoir systems; Supercritical CO_2 (SC-CO_2) phase behavior and subsurface storage conditions; Trapping mechanisms and storage permanence; Indian sequestration potential; Risk assessment and monitoring strategies	7	Understand geological carbon storage systems, trapping mechanisms, and subsurface carbon management strategies
2	**Geological Storage Systems, Injectivity and Geomechanical Integrity**: Deep saline aquifers, depleted oil and gas reservoirs, and adsorption-dominated storage systems; Injectivity behavior and transport characteristics during SC-CO_2 injection; Fluid–rock interaction and reservoir geomechanical response during carbon injection; Containment mechanisms and leakage pathways in low-permeability geological systems	6	Evaluate injectivity behavior, fluid–rock interaction, and storage integrity during SC-CO_2 injection
3	**CO_2 Storage Mechanisms & Pore-Scale Impacts**: Organic petrography and maceral controls on storage behavior; Porosity, permeability, and pore-throat connectivity in low-permeability systems; Darcy and non-Darcy flow behavior; Gas slippage and Klinkenberg effect; Fracture–matrix interactions and transport pathways; Fractal characteristics of adsorption-controlled pore systems; Multiscale pore complexity and storage behavior in organic-rich reservoir systems	6	Interpret pore-scale storage mechanisms, permeability behavior, and transport processes in low-permeability reservoir systems
4	**Advanced Reservoir Characterization Techniques:** Electron and Correlative Microscopy; 3D network reconstruction; Gas adsorption (N_2/CO_2), MIP, SAXS/SANS for pore quantification, AFM for nanomechanical characterization	5	Apply advanced analytical and multiscale imaging techniques for reservoir characterization and pore-network evaluation

5	**Interface Thermodynamics & Comparative Sorption**: Gibbs vs. Absolute adsorption; Mechanisms of gas desorption and sorption hysteresis; Capillary condensation vs. pore-blocking/evaporation effects; Thermodynamic derivation of adsorption isotherms: Langmuir, BET, DR, and DA models; Molecular modeling of adsorption/desorption: Fundamentals of Density Functional Theory (DFT) and Non-Local Density Functional Theory (NLDFT) for pore-size distribution (PSD) analysis; Monte Carlo (MC) and Grand Canonical Monte Carlo (GCMC) simulations of gas–solid interfaces; Isosteric heat of adsorption; Competitive sorption kinetics and selectivity; Sorption-induced matrix deformation	7	Analyze comparative sorption behavior and competitive adsorption processes in multicomponent gas systems
6	**Enhanced Hydrocarbon Recovery & Coupled Sequestration:** Fundamentals of Enhanced Oil Recovery (EOR) and Enhanced Gas Recovery (EGR); Thermal, chemical, microbial, and CO_2-EOR processes (overview); Competitive sorption-driven hydrocarbon displacement; Coupled sequestration–recovery dynamics in different reservoirs	7	Assess enhanced hydrocarbon recovery and coupled sequestration dynamics in reservoir systems
7	**Emerging Geological & Carbon-Negative Sequestration Pathways:** Enhanced Rock Weathering (ERW) and mineral carbonation; Biochar-mediated carbon stabilization in soil systems; In-situ thermal treatment of low-permeability horizons; Pyrolysis-driven carbon stabilization pathways; Geological hydrogen storage and cushion gas behavior; Integrated carbon-negative sequestration strategies	4	Appraise emerging carbon-negative strategies, including ERW, in-situ pyrolysis, and H_2 storage, to design integrated subsurface energy management protocols
	Total classes	**42**	

Text books:

- Baines, S.J. and Worden, R.H. (Eds.), Geological Storage of Carbon Dioxide, Geological Society, London.
- Rouquerol, J., Rouquerol, F., Llewellyn, P., and Sing, K., Adsorption by Powders and Porous Solids: Principles, Methodology and Applications, Academic Press.

Reference Books:

- Vishal, V. and Singh, T.N. (Eds.), Geologic Carbon Sequestration: Understanding Reservoir Behaviour, Springer.
- Zoback, M.D., Reservoir Geomechanics, Cambridge University Press.
- Frenkel, D. and Smit, B., Understanding Molecular Simulation: From Algorithms to Applications, Academic Press.
- Wilcox, J., Carbon Capture, Springer.
- Lake, L.W., Enhanced Oil Recovery, Prentice Hall.
- Gregg, S.J. and Sing, K.S.W., Adsorption, Surface Area and Porosity, Academic Press.