Indian Institute of Technology, Kanpur

Proposal for a New Course

1. Course No: CE6**

2. Course Title: Subsurface Environmental Flows

3. Per Week Lectures: 3 (L), Tutorial: 0 (T), Laboratory: 0 (P), Additional Hours [0-2]: 0 (A)

Credits: 3-0-0-0 (9)

Duration of Course: Full Semester

4. Proposing Department/IDP: Civil Engineering

Other Departments/IDPs which may be interested in the proposed course: Mechanical Engineering, Chemical Engineering, Earth Sciences, Sustainable Energy Engineering, Kotak School of Sustainability

Other faculty members interested in teaching the proposed course: None

5. Proposing Instructor(s): Chunendra K Sahu (Hydraulics and Water Resources group)

6. Course Description: PG course

A) ***Objectives***: The porous subsurface is crucial for various energy and environmental applications, including groundwater resources and carbon sequestration. This proposed course aims to introduce postgraduate and senior undergraduate students to the fundamental concepts of flow processes involved in these applications. We will specifically focus on five key areas: carbon sequestration, subsurface hydrogen storage, geothermal energy recovery, groundwater contamination, and subsurface nuclear waste storage. In this course, students will learn how to use the concepts of porous media flows for predicting flow behaviour in these contexts.

B) ***Contents*** (preferably in the form of 5 to 10 broad titles):

S. No	Broad Title	Topics	No. of 75 minutes Lectures
1	Introduction	Flow through porous media. Porous media properties. Governing equations. Confined and unconfined media. Miscible vs immiscible flows. Heterogeneity effects. Buoyancy effects. Instabilities.	4
2	Carbon sequestration	CCS process. Buoyancy effects. CO_2 plumes. Gravity currents. Convective dissolutions. Structural trapping. Capillary trappings. Rayleigh-Taylor instabilities and density fingers. Saffman-Taylor instabilities and viscous fingers. Leakage risks. Flow through fractures.	6
3	Subsurface Hydrogen storage	Hydrogen properties. Type of reservoirs. Storage in salt domes. Cushion gas. Storage in porous rocks. Migration and trapping. Cyclical operation. Leakage risks.	4
4	Geothermal energy recovery	Geothermal temperature gradients. Potential geothermal sites. Closed and open energy loop systems. Fluid front and thermal front. Geothermal heating and cooling.	5
5	Groundwater contamination	Dense plumes. Seawater intrusion into groundwater. Hydrodynamic dispersion. Effects of heterogeneity and background flow. Effects of density stratification.	5

S. No	Broad Title	Topics	No. of 75 minutes Lectures
6	Geological disposal of nuclear waste	Type of nuclear waste. Storage facility. Thermal-hydrological risks of leakage. Diffusion through cracks.	2
Total number of 75 minutes lectures			26

C) **Pre-requisites, if any**: Fluid Mechanics, Hydraulics, or Convective Heat Transfer.

D) **Short summary for including in the Courses of Study Booklet**: Introduction. Flow through porous media. Leakage through cracks. Carbon capture and sequestration. Underground Hydrogen storage. Geothermal energy recovery. Groundwater contamination. Subsurface nuclear waste storage. Hydrodynamic dispersion. Rayleigh-Taylor instabilities. Saffman-Taylor instabilities. Heterogeneity effects. Buoyancy and density-driven flows.

7. Recommended books:

Reference book

1. **Andrew Woods (2015). *Flow in Porous Rocks*. Cambridge University Press.**
2. **Kambiz Vafai (2005). *Handbook of Porous Media*. Taylor & Francis.**
3. **Jacob bear (1972). *Dynamics of Fluids in Porous Media*. Dover Publications.**

Proposer: Chunendra K Sahu

DPGC Convener:

Dated: 04/08/2025

Dated:_____

The course is approved / not approved

Chairperson, SPGC

Dated:_____