Course Type	Course No.	Course Name	L	T	P	C
DC1	NMNC507	Geomechanics for Underground Space	3	1	0	4

Course Objective

The students will learn theoretical and practical aspects of Geomechanics for use in their respective fields of specialization, work and research. Some of the course contents will be self-reading. The students will be encouraged to collect information on latest development in the field using our e-library and internet resources.

Learning Outcomes

- Upon successful completion of this course, students will have an understanding of various engineering properties of rocks and soil; engineering behavior of rocks and soil; concept of stress, strain and failure of rock; strength and deformability of rock mass; response of rock mass and soil to underground excavations; various ground control techniques in tunneling and rock engineering.
- Able to learn about the basics of theoretical and practical aspects of geomechanics and its importance in the design & operation of underground excavations for safe & productive tunneling and geo-engineering operations.

Units	Topics	Lecture Hours +Tutorials	Learning Outcome
UNIT-1	**Geotechnical Investigations and Classification of rock mass and soil:** Overview of requirements, methods and analysis of engineering-geological investigation methods Planning of exploration programs depending on the project stage, the requirements and the geological conditions Overview of appropriate investigation methods Rock mass classification methods and their applications Soil classification methods and their applications	(10L+2T)	Understanding of various engineering properties of rocks and soil; rock mass classification and soil classification methods and their application in the design of structures in rock and soil
UNIT-2	**Concept of Stress, strain and failure of rock:** Analysis of stress, Analysis of strain, Constitutive relations, Parameters influencing strength/stress-strain behavior. Failure Criteria for Rock and Rock Mass Classical theories of rock failure: Coulomb's criterion, Mohr's criterion, Griffith's theory, Cook-Wiebol's criteria; Empirical failure criteria. Behaviour of jointed rock mass (structure): Shear behaviour of discontinuities. Pre-excavation state of Stress, Stresses in rock mass, Factors influencing the in-situ state of stress, Estimating in situ stresses; Methods of Stress determination- Hydraulic fracturing, Relief, Jacking, Strain recovery and Borehole breakout techniques; Presentation of in situ stress measurement results.	(9L+3T)	This unit will help students to understand the concepts of stress at a point, strain at a point, and the stress-strain relationships for linear, elastic, homogeneous, isotropic materials. The students will solve practical problems through evaluating the relationship between stress and strain. understanding the concepts of different failure criteria of rock and rock mass and understanding of pre-mining stresses in rock and various methods of rock stress determination; its importance in tunnelling and design of various surface and underground structures in rock.

UNIT-3	**Soil behaviour:** Overview of shear strength and compressibility of soil, Lateral earth pressure theory, Soil conditioning	(3L+1T)	Understanding of various engineering properties of soil; soil classification methods, shear strength and behaviour of soils and their application in the design of structures in soil.
UNIT-4	**Response of rock mass and soil to excavation:** Response of rockmass to Excavations Underground, Induced stresses and displacements around single and multiple excavations in rock mass; Energy changes due to excavations in underground. Ground support interaction analysis and reinforcement of ground (rockmass and soil). **Slope Engineering:** Slope failure and causes and process; General modes of slope failure; Parameters related to slope stability; Basic approaches to slope stability analysis-circular, non-circular, planar, wedge and topping failures; Monitoring of slope stability. Monitoring of Excavation Stability Purpose and nature of monitoring excavation stability, Instrumentation and monitoring systems of stability of excavations-Load; Stress and Deformation measuring devices; Interpretation of monitoring data; Practical aspects of monitoring.	(10L+2T)	This unit will help students to understand about the response of rock mass and soil to excavations; design principles in rock excavation, selection of excavation methods, selection and design of support systems. The students will learn about the rock slope stability analysis and design for various tunnelling and rock engineering applications. Understanding of instrumentation and monitoring systems used in surface and underground rock excavations and tunnel stability.
UNIT-5	Rock and rock mass properties: Strength and Deformability of Rock Mass In situ shear tests; Evaluation of shear strength; In situ bearing strength test; In situ deformability tests-Plate Loading Test, Plate Jacking Test and Borehole Jack Tests Field measurement of soil properties.	(4L+2T)	Students will able to understand the deformability parameters of the jointed Rock mass with effects of discontinuities on its strength. and they will gain knowledge about the shear strength parameters of the Jointed Rock Mass, and also able to understand the in-situ tests and soil properties.
UNIT-6	**Miscellaneous:** Time –dependent deformation; Time –dependent strength reduction; Rheological models Groundwater flow: Permeability and pressure Groundwater flow within soil and rock masses; Permeability conditions; Influence of groundwater soil and rock masse behaviour; Measurement of groundwater pressure and permeability Rock bursts Type, effect and causes of rock bursts; Mechanics of rock burst; Prediction of rock burst; Control of rock burst incidence and damage Subsidence Types, causes and impacts of subsidence; Factors influencing subsidence; subsidence prediction, Control, prevention and monitoring	(8L+2T)	Students will able to understand the creep curves of rocks and rheological models. Understanding of groundwater flow within soil and rock and its influence on soil and rock mass behaviour; Measurement of groundwater pressure and permeability for design of rock excavations (tunnels etc.). Understanding of basic mechanics of rock bursts, various types of rock bursts and its prediction and control in mining operations and rock excavations at greater depths.

			Understanding of basic mechanics of subsidence, various types of subsidence and its prediction and control in underground excavations in rock.
	Total	42T+14T (56)	

Text Books:

1. Fundamental of Rock Mechanics by Jaeger, J.C. and Cook, NGW
2. An Introduction to Geotechnical Engineering by Robert D.Holtz, William D.Kovacs, Thomas C. Sheahan
3. Soil Mechanics by Lambe and Whitman

Reference Books:

1. Introduction to Rock Mechanics, Goodman, RE.
2. Underground Excavation in Rock by Hoek, E and Brown, ET
3. Rock Mechanics for Underground Mining, Brady, BHG and Brown, ET
4. Principles of geotechnical engineering, BM Das