Course Type	Course Code	Name of Course	L	T	P	Credit
DC (Hons)	NGLH404	Geostatistics & Mining Geology	3	1	0	4

Course Objective

This course provides fundamentals and application of statistics and geostatistics for mineral exploration and mineral reserve estimation. The course will also introduce the fundamental concepts of mining, essential for a geologist.

Learning Outcomes

Upon completion of the course, students will be able to:

- Learn basic statistics and probability density function for normal and log-normal distribution.
- Learn statistical test to accept and reject a hypothesis by statistical fit tests.
- Learn spatial correlation in properties of orebody such as grade, quantity, and distribution.
- Understand the fundamental of mining operation either in open cast or in underground mines.

Unit No.	Topics to be Covered	Lecture & Tutorial Hours	Learning Outcome
1.	Definition and nature of a random variable. Probability distributions: comparing discrete versus continuous. Key features used to describe a continuous distribution. Theoretical distribution models: Normal distribution , Lognormal distribution.	**5**	Grasping the statistical concepts specific to mineral deposits.
2.	Methods for assessing how well data fit a normal or lognormal distribution. Graphical approaches (e.g., Q-Q plots, P-P plots), numerical approaches (e.g., goodness-of-fit statistics). Hypothesis testing procedures: t-test, F-test, Chi-squared, goodness-of-fit test.	**6**	Learning statistical distribution, hypothesis testing.
3.	Geostatistics: core ideas and methods, regionalized variable, random function. Purpose and rationale for using geostatistical methods, stationarity assumption and the intrinsic hypothesis. Preliminary data quality checks.	**4**	Learning the core concepts and theories behind geostatistics.
4.	Semi-variogram analysis**,** definition and key properties of the semi-variogram, relationship between semi-variogram and co-variogram, features of an experimental semi-variogram. Computing semi-variograms in one, two, and three dimensions.	**6**	Performing spatial analysis to characterize patterns and properties in space.
5.	Common practical challenges in semi-variogram: directional dependence (spatial anisotropy), lack of stationarity and proportional effect, smoothing effects (regularization), discontinuity at the origin (nugget effect), presence of a systematic drift (trend).	**5**	Understand major practical challenges in semi-variogram.
6.	Variance components: extension, estimation, and dispersion, mathematical formulation, and computational approaches for extension-, estimation-, and dispersion-variance.	**5**	Learning what is estimation-variance-means and how to estimate it.
7.	Kriging fundamentals, introduction and definition of kriging, linear kriging methods: ordinary kriging and simple kriging. setting up and solving the kriging system for point support and block support. Key properties of kriging estimators.	**6**	Familiar with kriging systems of equations and their solutions, and practicing semi-variogram model fitting.
8.	Practical aspects of kriging, how the nugget effect influences kriging weights, shadow effect and screening effect, causes of negative kriging weight. Semi-variogram model fitting techniques, manual (hand) fitting, least squares fitting, point kriging cross-	**3**	Using kriging in practice to characterize natural resource deposits.

	validation Other kriging variants, brief introduction to other types of kriging.		
9.	Applications in mineral resource estimation, using geostatistics for mineral deposit evaluation, mineral inventory calculation, grade-tonnage relationships, role of kriging variance in optimizing exploration drilling programs, Handling misclassified tonnages, geostatistical grade control.	**2**	Understand application resource estimation, including, grade–tonnage relationships, and grade control.
10.	Mining geology, definition and scope, mining cycle, types of mines and common mining methods: surface vs underground, metallic and non-metallic, stages of mining operations, geological significance of rocks in mining, basics of structural geology for mining, ore control and structural mapping. Drilling methods (types), core logging, role of a mining geologist.	**4**	Fundamentals of mining geology, including the mining cycle, mining methods, geological controls of ore deposits, and structural mapping.
11.	Open cast / Open pit mining methods (benches, haul roads, and slopes), quarry mining (quarry layout and operations), strip mining (area strip and contour strip mining). Underground mining methods (room and pillar mining, longwall mining, stoping methods, caving methods, shaft and drift mining); placer and alluvial mining; solution and in-situ mining.	**3**	Principles and operations of major surface and underground mining methods, including open-pit, quarry, strip, stoping, caving, and longwall mining.
12.	Basics of mine development and operations (drilling and blasting, loading and hauling, ventilation in underground mines, mine drainage, roof support systems, shafts, adits, and tunnels), basics of mining equipment and machinery. Mine safety (mine hazards, accidents in mines, dust and gas hazards, personal protective equipment (PPE), mine safety regulations.	**4**	Fundamentals of mine development & operations, drilling, blasting, ventilation, drainage, roof support, and mining machinery.
13.	Sustainable mining, basic mining laws and regulations, mine closure, reclamation and rehabilitation, environmental impacts of mining, and mine waste management.	**3**	Principles of sustainable mining, environmental impacts of mining activities, and mine waste management practices.
	Total Classes	**56**	

Reference Books:

1. Isaaks Edward (1989). An Introduction to Applied Geostatistics. Oxford university press.
2. Marat Abzalov (2016). Applied Mining Geology.

Other Reference Books:

3. Sinclair, A.J. and Blackwell, G.H. (2002) *Applied Mineral Inventory Estimation*, Cambridge University Press.
4. David, M. (1977) *Geostatistical Ore Reserve Estimation*, Elsevier Scientific Publ. Co., Amsterdam.
5. Chiles, J.P. and Delfiner, P. (1999) *Geostatistics – Modelling Spatial Uncertainty*, John Wiley and Sons, New York.
6. Clark, I. (1979) *Practical Geostatistics*, Elsevier Applied Science Publ., London.
7. David, M. (1988) *Handbook of Applied Advanced Geostatistical Ore Reserve Estimation*, Elsevier, Amsterdam.
8. Davis, J.C. (1986) *Statistics and Data Analysis in Geology*, 2nd Edition, John Wiley & Sons, New York.
9. Gandhi, S.M. and Sarkar, B.C. (2016) *Essentials of Mineral Exploration and Evaluation*, Elsevier, USA.
10. Goovaerts, P. (1997) *Geostatistics for Natural Resources Evaluation*, Oxford University Press, Oxford.
11. Isaaks, E.H. and Srivastava, R.M. (1989) *An Introduction to Applied Geostatistics*, Oxford University Press.
12. Journel, A.G. and Huijbregts, C.J. (1978) *Mining Geostatistics*, Academic Press, London.
13. Wellmer, F.W. (1998) *Statistical Evaluation in Exploration for Mineral Deposits*, Springer, Hannover.