COURSE TYPE	COURSE CODE	NAME OF THE COURSE	L	T	P	CREDIT
DC	NFMC503	Process Metallurgy	3	1	0	4

COURSE OBJECTIVE
• This coursework aims to provide knowledge of various unit processes used in the metal extraction process from ore.
LEARNING OUTCOMES
• The students will understand the principles of various unit processes for metal extraction by pyrometallurgical, hydrometallurgical and electrometallurgical routes. • Students will learn different extraction, separation and purification methods and understand the process flowsheet for extracting various metals.

NO.	TOPICS TO BE COVERED	LECTURE HOURS	TUTORIAL HOURS	LEARNING OUTCOME
1	**Introduction to process metallurgy:** Introduction to ores and minerals, mode of occurrence of metals in nature, aims of extractive metallurgy, ore concentration, and reactivity series.	6	1	Difference in ores and minerals, ores of common metals, general flowsheet for extraction of metals from ores.
2	**Pyrometallurgy:** Principles of Pyrometallurgy, Ellingham diagram, Equilibrium oxygen pressure, Nomographs, Unit operations in Pyrometallurgy, Calcination, Roasting, Predominance area diagram, Smelting, Metallothermic reduction, Matte Smelting, Slag structure, Agglomeration.	9	4	Fundamentals of pyrometallurgy and principle of different unit processes. Advantages and limitations of pyrometallurgical processes.
3	**Hydrometallurgy:** Principles of Hydrometallurgy, Leaching, E_H-P_H diagram, Pressure leaching, Commercial leaching operations, leaching kinetics, Shrinking core model, Cementation.	9	2	Fundamentals of hydrometallurgy and principle of different unit processes used to recover metals from ore to the aqueous solution. Criteria for selecting pyro/hydro route for metal extraction.

4	**Metal purification methods:** Solvent Extraction, type of extractants, extraction mechanism, Distribution ratio and selectivity, Stripping, and ion exchange process.	4	1	Different methods to remove impurities from aqueous solution and to obtain high pure solution of desired metal ions.
5	**Electrometallurgy:** Principles of electrolysis, Electro-winning and Electro refining, Molten salt electrolysis process.	3	2	Principles of electrometallurgical processes, electrolysis of different metals in aqueous and molten salt medium.
6	**Extraction Processes of major metals:** Basics of iron making, extraction processes for non-ferrous metals such as copper, aluminum, zinc, lead etc. Properties and uses of these metals for industrial applications.	11	4	Understanding of typical/conventional process flowsheet used for the extraction of different metals in the industry.
	Total	**42**	**14**	**56**

TEXT BOOKS:

1. First Course in Iron and Steel Making by Dipak Mazumdar, Universities Press
2. Iron Making and Steelmaking: Theory and Practice by Ahindra Ghosh, Amit Chatterjee, PHI Learning Pvt. Ltd.

REFERENCE BOOKS:

1. Principles of Extractive Metallurgyby A Ghosh, H S Ray, New Age International
2. Extraction of Nonferrous Metals by H. S. Ray, R. Sridhar, K.P. Abraham, Oscar Publications
3. Hydrometallurgy by S. Venkatachalam, Narosa Publishing House
4. Engineering in Process Metallurgy by R.I.L. Guthrie, Oxford University Press
5. Unit Processes in Extractive Metallurgy by R D Pehlke, Elsevier
6. Process Selection in Extractive Metallurgy by Peter Hayes, Hayes Publishing Co.