Savitribai Phule Pune University

Pune, Maharashtra India

Structure and Syllabus of Three Years B.Sc Program in Geology with Multiple Entry and Exit Option

THREE YEAR BACHLORS PROGRAMME IN SCIENCE

Subject: **GEOLOGY**

Under the Faculty of

Science and Technology

Ref: BOS Geology held on 27th April 2024; Academic held on 3rd May 2024)

Effective from Academic year 2024– 2025

(As per NEP-2020)

Title of the Program: F.Y.B.Sc. Geology Syllabus.

Program Level: First year of 3-year B.Sc. Geology Degree Program

Syllabus to be implemented from the Academic year: 2024-25

Preamble:

Our Earth is a cosmic body. It is one of the eight members of the Solar System. Geology is a science that deals with the study of the Earth. The subject of geology deals with the origin, history, and evolution of the Earth. It also deals with its materials (rocks, minerals, ores, metals, coal, and petroleum deposits etc.) that constitute it, and the processes, both external and internal, that operate on, and within it. Since the inception of this branch of Science, Geology has remained a field of active research and has expanded in all possible directions. It is broadly categorized as pure and interdisciplinary science. Since geology is a very vast and varied subject, for better understanding it has been divided into a number of branches. The fundamental branches of Geology are Mineralogy, Petrology, Dynamic Geology, Physical Geology, Structural Geology, Economic Geology, Palaeontology, Stratigraphy. The applied branches of Geology are Hydrogeology, Geotectonics, Coal Geology, Petroleum Geology, Marine Geology, Environmental Geology, Mining Geology, Geomorphology, Geochemistry, Geophysics, Oceanography, Seismology, Gemmology, Engineering Geology, Photogeology (Remote Sensing), Historical Geology, Rock Mechanics, Nuclear Geology, Medical Geology. Natural resources and their proper exploitation play a vital role in nation building. All the natural resources except the solar energy are directly linked with the earth. Therefore, knowledge of different aspects of Geology has become crucial and indispensable to everyone in the society and will help man to manage the available resources and conserve them in the best possible way. There is a continual demand for Geologists in the workforce- education, industry, and research. Career opportunities for the graduate students are available in the private and government enterprises, research institutes and as self-consultants in the fields of groundwater, soil analysis, gemmology, cutting and polishing of semi-precious stones, trading of building materials, small scale mining etc. Also, multinational oil companies are recruiting qualified petroleum geologists.

Program Specific Outcomes (PSOs) for B. Sc. Geology Program	
PSO 1	Acquire a solid base of knowledge in the science of geology as well as earth materials, earth history, sedimentation and stratigraphy, deformational processes and structural features, and geomorphic processes and landforms
PSO 2	Know the geologic time scale and place important geologic events in a temporal framework.
PSO3	Understand the pathways, fluxes, and influence of water and other fluids a Earth's surface and the subsurface.
PSO 4	Interpret topographic/Geological maps and terrain models and create profiles and construct Cross Sections.
PSO 5	Develop the aptitudes and dispositions necessary to help democratize society by obtaining and maintaining employment as a professional geologist.

Introduction

The present syllabus is sufficient to meet the needs of students for building up their careers in

Program Outcomes (POs) for B. Sc. Program	
PO 1	Domain knowledge: Establish a thorough understanding of the subjects that comprise a graduate study. Execute strong theoretical and practical knowledge gained from a specialized degree program in the field of work.
PO 2	Critical Thinking and Problem: Solving: Demonstrate the analytical, inference, interpretation, and problem-solving abilities by thoroughly studying the issue and creating solutions.
PO3	Effective Citizenship and Ethics: Demonstrate empathetic social concern and equity-centred national development, and the ability to act with an informed awareness of issues and participate in civic life through volunteering. Recognize different value systems including your own,
PO 4	Environment and Sustainability: Understand the issues of environmental contexts and sustainable development.
PO 5	Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes

Geology. However, looking at the changing scenario at a local and global level, and due to the very existence of the earth which has been threatened by calamities like earthquakes, volcanic eruptions, landslides, floods, tsunamis or droughts, which are directly or indirectly related to geological action on the surface or subsurface. Also looking at the fast-depleting natural inorganic resources and the fuel deposits, it has become imperative that geology which incorporates the science of these natural hazards and the associated disasters should be taught rather effectively at the under-Graduate and Post-Graduate levels. Awareness related to the modern concepts of Plate Tectonics, Remote Sensing, and Geographical Information System (GIS) etc. is a must for all Geology graduate students. Theoretical knowledge supplemented with extensive laboratory expertise and field training will help the students, to avail all opportunities available and even start their own consultancy firms. Therefore, revision and

updating of the curriculum is an essential component and a continuous process of any university system. There has to be a dynamic curriculum with necessary re-orientations, additions and modifications introduced in it from time to time by the respective university so that it is compatible and in tune with the fast-paced developments in the subject. It should be able to provide easy placement opportunities for the students and also good avenues for research activities. Introduction of innovative concepts, providing a multidisciplinary profile in the concerned subject and an updated education to the students at large should be the prime aim while revising/renewing the curriculum. Geology curricula are operated at two levels viz undergraduate and postgraduate. The undergraduate curricula are prepared to impart basic and fundamental concepts of the subject Geology from all possible aspects. In addition, field training will have a priority since geology is basically a field science and more practical exposure will benefit the student community at large and produce good geologists for the nation.

Objectives to be achieved:

1. To help students' build-up a progressive and successful career in Geology
2. To enrich students' knowledge and train them in the pure geological sciences.
3. To Provide an updated education.
4. To impart more field-oriented knowledge.
5. To inculcate sense of scientific, social responsibilities and environment awareness.
6. To introduce the concepts of application and research in Geology.
7. Create a sense of preservation and conservation of natural resources.
8. To study structural dynamics of the earth.
9. To study Stratigraphy and Palaeontology that encompasses the aspects of the age of the earth, chronological arrangement of rocks and appearance and evolution of life through the geologic time.
10. To study the changes that occurred in the history of the earth and relate them to their field observations and, in understanding the framework of the stratigraphy of India
11. To study basics of mineralogy and crystallography, which helps in understanding and building the overall knowledge in Geology.
12. To study the processes involved in the formation of igneous, sedimentary, and metamorphic rocks, their textures, structures, classifications and their importance.
13. To study the dynamic nature of the Earth processes.
14. To study the geodynamics of the lithosphere and concept of isostacy, ocean floor spreading, continental drift and plate tectonics.

Faculty of the Program: Science

Eligibility for Admission:

First Year B.Sc.:

Higher Secondary School Certificate (10+2) or its equivalent Examination
Or as per the SPPU eligibility norms.
Note: Admissions will be given as per the selection procedure / policies adopted by the respective college, in accordance with conditions laid down by the SPPU
Reservation and relaxation will be as per the Government rules.

Medium of Instructions: English

Credit Framework

Proposed Credit Framework for Under Graduate (UG) (2024-25) (3 Subject) for GEOLOGY in faculty of Science and Technology (SPPU)

B. Sc. in Geology (Certificate/Diploma/Honours)

Level/ Difficulty	Sem.	Course Type	Course Code	Course Title (Brief on contents/levels)	Theory/ Practical	Credit	Hrs
4.5/100	I	Subject -1, 2 or 3	GL 101 MJ	**Mineralogy and Crystallography**	Theory	2	30
			GL 102 MJP	**Practicals related to GL 101 MJ**	Practical	2	60
		Generic Elective (GE) / Open Elective (OE) - (Any one from basket)	GL 111 OE	**Minerals and Gems**	T/P	2	30/60
			GL 112 OE	**Introduction to Earth Science**	T/P		
			GL 113 OE	**Introduction to Geohazards**	T/P		
		Skill Enhancement Courses (SEC)	GL 121 SEC	**Earth System Science**	Theory	2	30
		Indian Knowledge System	GL 131 IKS	**Generic**	Theory	2	30
		Ability Enhancement Course (AEC)	GL 132 AEC	**English Language**	T	2	30
		Vocational Education Courses (VEC)	GL 141 VEC	**Environmental Geology and Sustainability**	Theory	2	30
4.5/100	II	Subject	GL 151 MJ	**Petrology I**	Theory	2	30
			GL 152 MJP	**Practicals related to GL 151 MJ**	Practical	2	60
		Generic Elective (GE) / Open Elective (OE) - (Any one from basket)	GL 161 OE	**Introduction to Rocks**	Theory	2	30
			GL 162 OE	**Study of Landforms**	Theory	2	30
		Skill Enhancement Courses (SEC)	GL 171 SEC	**Gemmology**	Practical	2	60
		Ability enhancement Course (AEC)	GL 181	**Languages Course**	Theory	2	30
		Vocational Education Courses (VEC)	GL 191 VEC	**Optical Mineralogy**	Theory	2	30
		Curricular Course (CC)	GL 200 CC	**NCC/NSS/Sports/Cultural/Yoga Study**	Theory	2	30
Exit Option: Award of UG Certificate in Major with 44 credits core NSQF course/internship OR continue with Major and Minor. **Continue Option:** Student will select one subject (Subject1, 2 or 3) as major and another as minor and third subject will be dropped.							
5.0/200	III	Major Core	GL 201 MJ	**Introduction to Stratigraphy**	Theory	2	30
			GL 202 MJ	**Structural Geology**	Theory	2	30
			GL 203 MJP	**Practicals related to GL 201 MJ & 202 MJ**	Practical	2	60

		Vocational Skill Courses (VSC)	GL 211 VSC	**Hydrogeology**	Theory	2	30
		Field Project (FP)	GL 220 FP	**Mapping, Surveying and Field Project**	T/P	2	
		Minor	GL 221 MN	**Introduction to Structural Geology**	Theory	2	30
			GL 222MNP	**Practicals related to GL 221 MN**	Practical	2	60
		Generic Elective (GE) / Open Elective (OE) (Any one from basket)	GL 231 OE	**Gemmology**	Theory	2	30
			GL 232 OE	**Introduction to Natural Resources**	Theory	2	30
		IKS (Major Subject Specific)	GL 241 IKS	**Ancient Knowledge System in Geosciences**	Theory	2	30
		AEC (Ability Enhancement Course)	GL 242 AEC	**Modern Indian Languages**	Practical	2	30
		Curricular Course (CC)	GL 245 CC	**NCC/NSS/Sports/Cultural/Yoga Study**	T/P	2	30
5/200	**IV**	**Major Core**	GL 251 MJ	**Petrology II**	Theory	2	30
			GL 252 MJ	**Tectonics**	Theory	2	30
			GL 253 MJP	**Practicals related to GL 251 MJ & GL 252 MJ**	Practical	2	60
		VSC	GL 260 VSC	**Industrial Mineralogy and Critical Minerals**	Theory	2	
		FP	**GL 265 FP**	**CEP**	T/P	2	30
		Minor Courses	GL 271 ME	**Dynamics of the Earth**	Theory	2	30
			GL 272MNP	**Practicals related to GL 271 MN**	Practical	2	60
		Skill Enhancement Courses (SEC)	GL 281 SEC	**Exploration Geology**	T/P	2	30
		Curricular Course (CC)	GL 285 CC	**NCC/NSS/Sports/Cultural/Yoga Study**			
		Ability Enhancement Program (AEC)	GL 290 AEC	**Languages**	Theory	2	30
		Generic Elective (GE) / Open Elective (OE) - (Any one from basket)	GL 295 OE	**GIS and Geoinformatics**	Practical	2	60
			GL 296 OE	**Water Resource Management**	Practical		60
Exit Option: Award of UG diploma in Major and Minor with 88 credits and an additional 4 credits core NSQF course/Internship OR continue with Major and Minor							
5.5/300	**V**	**Major Core**	GL 301 MJ	**Geology of India**	Theory	4	60
			GL 302 MJ	**Engineering Geology**	Theory	2	30
			GL 303 MJ	**Palaeontology**	Theory	2	30
			GL 304 MJP	**Practicals related to GL 301 to GL 303 MJ**	Practical	4	120
		Major Elective Courses	GL 311 ME	**Micropalaeontology**	Theory (Select One from Basket)	2	30
			GL 312 ME	**Oceanography and Marine Geology**		2	30
			GL 313 ME	**Geomorphology**		2	30

			GL 314 ME	**Quaternary Geology**		2	30
			GL 315 MEP	**Elective Practical related to GL 311 MJ/ GL 312 MJ/ GL 313 MJ/ GL 314 MJ**	Practical	2	60
		Vocational Skill Courses (VSC)	GL 321 VSC	**Natural Disaster Management**	T/P	2	30
		FP/CEP	GL 331 FP	**Field Project and Scientific Report Writing**	T/P	2	30
		Minor	GL 341 M	**Petroleum Geology**	T	2	30
5.5/300	**VI**	**Major Core**	GL 351 MJ	**Remote Sensing in Geosciences**	Theory	2	30
			GL 352 MJ	**Economic Geology and Mineral Economics**	Theory	2	30
			GL 353 MJ	**Climatology**	Theory	2	30
			GL 354 MJ	**Petroleum and Coal Geology**	Theory	2	30
			GL 355 MJP	**Practicals related to GL 351 MJ & GL 352 MJ**	Practical	4	120
		Major Elective Courses	GL 361 ME	**Geotechnical Studies**	Theory (Select any One from Basket)	2	30
			GL 362 ME	**Watershed Management**		2	30
			GL 363 ME	**Analytical Methods in Geology**		2	30
			GL 364 ME	**Introduction to GIS- Open Source**		2	30
			GL 365 MEP	**Elective Practical related to GL 361 to 365**	Practical	2	60
		VSC	GL 371 MN	**GIS and Geoinformatics**	T/P	2	30
		OJT	GL 375 OJT	**ON Job Training**		4	
Exit Option: Award of UG Degree inn Major with 132 credits OR Continue with Major and Minor							
6.0/400	**VII**	**Major Core**	GL 401 MJ	**Theory 1, Theory 2, Theory 3**		6	90
			GL 401 MJP	**Practicals related to theory**		4	120
		Major Elective Courses - (0C)	GL 411 ME	**Theory**		2	
			GL 412 P	**Practical**		2	
		FP/OJT/CEP/RP	GL 421 FP	**Research Project**		4	
		Research Methodology	GL 431 RM	**Research Methodology**		4	
6.0/400	**VIII**	**Major Core**	GL 451 MJ	**Theory1 , Theory 2, Theory 3**		6	90
			GL 452 MJP	**Practical**		4	120
		Major Elective Courses - (0C)		**Theory**		2	
				Practical		2	
		FP/OJT/CEP/RP	GL 461	**Research Project**		8	

Four Year UG Honours with Research Degree in Major and Minor with 176 credits OR

6.0/400	**VII**	**Major Core**	GL 401 MJ	**Theory**		10	150
			GL 402 MJP	**Practical**		4	120
		Major Elective Courses - (0C)	GL 411 ME	**Theory**		2	
				Practical		2	
		Research Methodology	GL 421 RM	**Research Methodology**	T	4	
6.0/400	**VIII**	**Major Core**	GL 451 MJ	**Theory**		10	150
			GL 452 MJP	**Practical**		4	120
		Major Elective Courses	GL 461	**Theory**		2	
			GL 462	**Practical**		2	
		FP/OJT	GL 471	**OJT**		4	

Four Year UG Honours Degree in Major and Minor with 176 credits

Notes: OE to be compulsorily chosen from faculty other than that of Major

Abbreviations

OE: Open Elective
AEC: Ability Enhancement Course
VEC: value Education Courses
CC: Co-Curricular Courses
CEP: Community Engagement Project
IKS: Indian Knowledge System
OJT: On Job Training
FP: Field Project
VSC: Vocational Skill Courses

Intake Capacity of Students: As per U.G.C. norms

Course Implementation criteria for Theory and Practical:

a. Each semester comprises of 15 weeks (12 weeks Actual Teaching + 3 weeks for Continuous Internal Evaluation).

b. One Credit of the Theory is equal to15 clock hours (Teaching 1 hour per week for each credit, 12 hours Actual Teaching + 3 hours Continuous Internal Evaluation – Assignments, Tutorials, Practice, Problem solving sessions, Group discussion, Seminars and Unit Tests.

c. One Credit of Practical = 30 clock hours. (2 Contact hours per credit per week)
One Credit = 30 clock hours (24 hours' Actual Table work + 6 hours for journal competition, and Continuous Internal Evaluation of each practical).

d. Practical for each course comprises of 02 Credits = 60 clock hours. Therefore,

- Minimum 12 laboratory sessions of 04 clock hours must be conducted in one semester.
- In case of short practical, two practicals should be conducted in one session.

Examination: As per pattern finalization need to change : 80:20 or 70:30 or 60:40

For 2 Credit Course:

Theory paper: University Examination – 35 marks (at the end of each semester)
Internal Examination – 15 marks
Practical course: University Examination – 35 marks (at the end of each semester)
Internal Examination – 15 marks
Theory examination will be of two hours duration for each theory course.

The pattern of question papers shall be as per SPPU Guidelines

For 4 Credit Course:

Theory paper: University Examination – 70 marks (at the end of each semester)
Internal Examination – 30 marks
Practical course: University Examination – 70 marks (at the end of each semester)
Internal Examination – 30 marks
Theory examination will be of three hours duration for each theory course.
The pattern of question papers shall be as per SPPU Guidelines
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I. Pattern of Examination:
i. Internal exam, Practical, Oral, Project.
ii. Pattern of the question paper: As per University rules
II. Standard of Passing: As per University rules

External Students: There shall be no external students.

Setting of Question Paper/Pattern of Question Paper: As per SPPU guidelines

Verification/Revaluation: As per SPPU rules

Semester I
GL 101 MJ MINERALOGY AND CRYSTALLOGRAPHY (2 Credits)

Title of the Course and Course Code	**Mineralogy and Crystallography GL 101 MJ**	**Credits:02**
Course Learning Outcomes (CLOs) On completion of the course, the students will be able to:		
CLO1	To study basics of mineralogy and crystallography which helps in understanding and building the overall knowledge in Geology	
CLO2	To identify common rock-forming minerals in hand specimens as well as in thin sections.	
CLO3	Describe various Physical properties, Optical properties, crystal parameters in minerals and crystal models.	
CLO4	To study the details of Crystals and its geometric arrangement	
CLO5	Explain industrial applications and economic importance of various minerals	

Unit/ Hour	**Contents**	**No of Lectures**
I/15	**Introduction To Minerals:** Definition, branches and scope of mineralogy. Importance and conservation of minerals. **Formation of minerals:** Crystallization from melt. Crystallization from Solution(evaporation and precipitation).Crystallization from Vapour (sublimation),Metamorphic processes, Alteration and related weathering (oxidation and supergene sulphide enrichment). **Natural and Synthetic Minerals** **Properties Of Minerals:** **Physical properties of minerals:** Colour, Diaphaneity, streak, lustre, cleavage and partings, fracture, form, habit, tenacity, hardness and specific gravity, Methods of determining specific gravity. Properties based on magnetism, electrical properties, and radioactivity, Luminescence (Phosphorescence and Fluorescence) **Optical properties of minerals:** **Nature of light:** – ordinary and plane polarized light, Double¬ refraction of light (with the help of calcite crystal), Nicol's prism and polaroids, Petrological microscope, Opaque and Non opaque Minerals, **Introduction to optical properties: –** **In plane polarized light**: Colour, form, cleavage, cracks, relief, twinkling, pleochroism **In between crossed nicols:** Isotropism, anisotropism, extinction positions (straight, oblique, symmetrical and determination of extinction angle), interference colours, twinning (simple, multiple and cross hatching).	**15**
II/15	**Crystal Chemistry and Crystallography** **Crystal Chemistry** Major element constituting of minerals. Geochemical affinity & geochemical classification of elements. Isomorphism, Polymorphism, Pseudomorphism. Silicate structures **Crystallography** Definition and conditions conducive for the formation of crystals.	**15**

	Crystal morphology - faces, forms, edges, solid angles, interfacial angle and its measurement by contact Goniometer, law of constancy of interfacial angle. Symmetry of crystals - Elements of Symmetry-Plane, axis and center of symmetry; crystallographic and geometrical symmetry. Crystallographic axes, lettering and order of crystallographic axes, parameters, axial ratio, indices, parameter system of Weiss, index system of Miller, Law of rational indices. Study of following crystallographic systems with respect to their elements of symmetry, crystallographic axes and their forms with indices. Orthorhombic (Type: Barytes), Tetragonal (Type: Zircon), Cubic (Type: Galena), Hexagonal (Type: Beryl), Monoclinic (Type: Gypsum), Triclinic (Type: Axinite)	

Suggested Readings:

References:

1. Read, H.H., (1968)Rutley's Element of Mineralogy (Rev. Ed.). Thomas Murby and Co.
2. Text Book of Mineralogy: Dana and Ford
3. Manual of Mineralogy: Cornelius, S. Hurlbut and Cornel Klein
4. Ram S. Sharma and Anurag Sharma (2013) Crystallography and Mineralogy - Concepts and Methods. Text Book Series, Geological Society of India, Bangalore
5. Dana, E.S. and Ford, W.E., (2002) A textbook of Mineralogy (Reprints).
6. Phillips, F.C., (1963) An introduction to crystallography. Wiley, New York
7. Berry, L.G., Mason, B. and Dietrich, R.V., (1982) Mineralogy. CBS Publ

GL 101 MJP PRACTICALS RELATEDTO GL 101 MJ
(2 Credits)

Title of the Course and Course Code	**Practicals related to GL 101 MJ GL 102 MJP**	**Credits:02**

Topics	**No. of Practicals**
Mineralogy **A)** Physical properties of minerals: Colour, form, streak, luster, cleavage, fracture, hardness and specificgravity.	9
B) Identification of following **Megascopic minerals** in hand specimens withthe help of physical properties: Quartz, Rock crystal, Rose Quartz, Milky Quartz, Smoky quartz, Amethyst, Chalcedony, Agate, Jasper, Flint, Opal, Orthoclase, Plagioclase, Biotite, Muscovite, Garnet, Olivine, Hornblende, Apophyllite, Stilbite, Kyanite, Talc, Calcite, Fluorite, Gypsum, Baryte.	
C) Optical Mineralogy: Study of optical properties of minerals in plane polarised light and between crossednicols.	
D) **Microscopic minerals:** Olivine, Augite, Hornblende, Microcline, Plagioclase, Muscovite, Biotite,Calcite, Garnet, Quartz and Orthoclase.	

Crystallography Study of elements of symmetry, crystallographic axes and forms with indices of the following crystal systems representing all the fundamentalcrystal forms: Cubic System (Type: Galena) Orthorhombic System (Type: Baryte) Tetragonal System (Type: Zircon) Hexagonal System (Type: Beryl) Monoclinic (Type: Gypsum)	6
Total No. of Practicals	15

GL 111 OE MINERALSAND GEMS (2 Credits)

Title of the Course and Course Code	**Minerals and Gems** **OE 101 GL**	**Credits:02**
Course Learning Outcomes (COs) On completion of the course, the students will be able to:		
CLO 1	Students will learn Mineral science	
CLO 2	Describe various physical properties, optical properties, crystal parameters in minerals and crystal models.	
CLO 3	Explain industrial applications and economic importance of various minerals.	
CLO 4	Describe importance of minerals and their formation.	
CLO 5	Understand the fundamentals of various precious and semiprecious gem stones.	
CLO 6	Know their formation, classifications, basic qualities of gemstones, description of their various physical properties.	
CLO 7	Learn about the different techniques involved in identification of natural and synthetic gemstones and and enhancement treatments.	
CLO 8	Learn about the formation of gems. Know the various gem testing methods;Understand the physics of colour. Learn how to measure gemstones; Familiarise yourself with the most precious gemstones.	

Unit/ Hour	**Contents**	**No of Lectures**
I/15	Minerals Definition, branches and scope of mineralogy. Importance and conservation of minerals. Formation of minerals: Introduction and description of geological processes of mineral formation Crystallization from melt, Crystallization from Solution (Evaporation and precipitation), Crystallization from Vapour. (Sublimation), Metamorphic processes, Alteration and related weathering. (Oxidation and supergene enrichment) Physical properties of minerals :Colour, streak, luster, cleavage, fracture, hardness, form, specific gravity etc. Introduction Optical Mineralogy Utility of Minerals in Industries: Ceramic, Refractory, Pharmaceutical, Paint, Glass, Cement, Fertilizer, Oil Industry, Electrical and Electronics	**15**

II/15	Gemmology 1) Introduction to Gems- Basic properties of gems- Formation of gem stones. 2) Introduction to gem species with respect to their varieties 3) Opaque, rare, organic gem varieties. 4) Gem synthesis and distinction between Synthetic and Natural gem stones. Gem Testing Instruments Gem instruments: Hand lens (10x), Dichroscope, Refractometers, Polariscope. Causes of colours in gem stones	**15**

Suggested Readings:
References:

1. Karanth R.V (2000) Gems and Gem Industry in India, Geological society of India
2. Read, P. G.(1991) Gemmology, Butterworth-Heinemann Ltd.
3. Webster, R. and edited by Anderson, B.W. (1983) Gems: Their Sources, Descriptions and Identification, Butterworth-Heinemann Ltd
4. Sinkankas, J. (1969) Mineralogy: A First Course, Van Nostrand Reinhold Company.
5. Karanth R.V (2008) Gemstones Enchanting Gifts of Nature, Geological society of India.

GL 112 OE INTRODUCTION TO EARTH SCIENCE (2 Credits)

Title of the Course and Course Code	**Introduction to Earth Science OE 102 GL**	**Credits:02**
Course Learning Outcomes (CLOs) On completion of the course, the students will be able to:		
CLO 1	Students will learn different branches of Geology and its Scope.	
CLO 2	Student will get an idea of the Solar system in relation to the evolution of the earth, and an overall idea about cosmology in context to the evolution of planetary system	
CLO 3	Familiarize with the structure, composition and general characteristics of the lithosphere, hydrosphere, atmosphere and biosphere.	
CLO 4	Student will learn in detail about the fundamental physical and chemical properties of the earth and its variation with the interior.	
CLO 5	Student will know the applications of the physical and chemical properties in understanding the evolution of the earth.	
CLO 6	Students will learn the interior structure of the earth and plate movements.	
CLO 7	Student will get an idea of the external agents, processes of deposition and erosion of the earth's surface.	

Unit/ Hour	**Contents**	**No of Lectures**
I/15	**Introduction to Geology:** Definition of Geology, its divisions, sub-divisions and scope **Planet Earth** Origin of the Universe (Big Bang Theory), Origin of the Solar System. Earth: Origin Its size, shape and density. Age of the Earth	**15**

	Earth's Atmosphere: (Introduction, Classification of Atmosphere) Hydrosphere (Introduction to ocean currents, types, causes and significance) Lithosphere (Structure and composition) Biosphere (Ecology and food chain) Earth's Crust, Mantle and Core **Geological time scale:** Concept and Criteria, Mass Extinction	
II/15	**Weathering, erosion and denudation** Types of weathering: Mechanical – frost wedging, frost action, insolation, activities of organic life and exfoliation Chemical-hydrolysis, hydration, solution, carbonation and oxidation Rock deformation (Definition, Stress, Types of differential stress; Strain; Types of deformation; Types of Forces; Introduction to Fold, Fault, Joints and Fracture) Continental Drift: Concept and evidences – continental fit, Geological and palaeontological. Plate Tectonics: A brief introduction.	**15**

Suggested Readings:
References:

1. Holmes'Principles of Physical Geology: Edited by P. McL. D. Duff
2. Plate tectonics and Crustal evolution: Condie
3. Our evolving planet: Bergen, Alma Mater Fortag
4. Geomorphology and Global Tectonics: Summerfield M. A.
5. Geomorphology: Thornburry
6. Concepts of Geomorphology: Gupta and Kale

GL113 OE INTRODUCTION TO GEOHAZARDS (2 Credits)

Title of the Course and Course Code	**Study of Geohazards OE 103 GL**	**Credits:02**
Course Outcomes (COs) On completion of the course, the students will be able to:		
CLO 1	Understand the fundamental concepts Geohazards and its importance	
CLO 2	Thoroughly exposed to the concept of extreme events and catastrophic geological hazards like landslides, subsidence, floods, droughts, earthquakes, and volcanoes.	
CLO 3	Different hazards posing danger to coastal areas like cyclones, tsunamis, and shoreline and sea level changes are also studied.	
CLO 4	Understand the role of plate tectonics in causing geohazards and how this understanding can aid the assessment of seismic hazard.	

Unit/ Hour	Course Contents	No of Lectures
I/15	**Geo Hazards I :** Definition, Types, Prediction, Natural hazard zones and impact assessment, Natural hazard zonation maps, Significance of Geology in Disaster Management Earthquakes: Terminologies, Causes, Intensity & magnitude Scales, Building codes and public education Volcanic Hazards: Origin and types of volcanic activity, Nature of volcanic hazards, Prediction of volcanic eruptions, and mitigation of volcanic hazards. Cyclones and Floods: Introduction, definition, classification, causative factors, vulnerability, predictability (forecasting), mitigation measures, Cyclone and flood hazards in India Technological approaches (e.g., dams and levees) and land-use planning approaches to avoiding flood damages	15
II/15	**Geo Hazards II :** Droughts, meteorological, agricultural and hydrologic types, mitigation of droughts Introduction, causes and types of mass movements, Identification **o**f landslides zones, control measures, avalanches and their causes, mitigation and concept of safety factor Evaluation of technologies for landslide prevention **Coastal hazards:** Introduction, causes and impacts of coastal erosion, tsunami, storms and their predictability and mitigation measures **Subsidence of land:** Causes of subsidence of land, prediction and mitigation measures Role of Geologist in disaster management plan	15

Suggested Readings:
References:

1. Verma, V.K., (1986) Geomorphology Earth surface processes and form. McGraw Hill.
2. Chorley, R. J., (1984) Geomorphology. Methuen.
3. Selby, M.J., (1996) Earths Changing Surface. Oxford University Press UK.
4. Thornbury W. D., (1997) Principles of Geomorphology Wiley Eastern Ltd., New Delhi.
5. Valdiya, K. S., (1987) Environmental Geology - Indian Context. Tata McGraw Hill New Delhi.
6. Keller, E. A., (2000) Environmental Geology. Shales E. Merril Publishing Co., Columbus, Ohio.
7. Montgomery, C., (1984) Environmental Geology. John Wiley and Sons, London.
8. Bird, Eric, (2000) Coastal Geomorphology: An Introduction. John Wiley & Sons, Ltd. Singapore.
9. Liu, B.C., (1981) Earthquake Risk and Damage, Westview.
10. Sharma J. P., Environmental Studies, Laxmi Publications (P) Ltd, New Delhi

GL121 SEC EARTH SYSTEM SCIENCE (2 Credits)

Title of the Course and Course Code	**Earth System Science SEC 101 GL**	**Credits:02**
Course Learning Outcomes (CLOs) On completion of the course, the students will be able to:		
CLO 1	Students will learn different branches of Geology and its Scope.	
CLO 2	Student will get an idea of the Solar system in relation to the evolution of the earth, and an overall idea about cosmology in context to the evolution of planetary system	
CLO 3	Student will know the applications of the physical and chemical properties in understanding the evolution of the earth with the interior.	
CLO 4	Student will learn about the magnetic field of the earth.	
CLO 5	origin, history and evolution of the Earth	
CLO 6	Familiarize with the structure, composition and general characteristics of the lithosphere, hydrosphere, atmosphere and biosphere.	
CLO 7	Students will learn the interior structure of the earth and plate movements.	
CLO 8	Student will get an idea of the types of forces, processes of rock deformation.	
Unit/ Hour	**Contents**	**No of Lectures**
I/15	**Introduction to Geology:** Definition of Geology, its divisions, sub-divisions and scope **Planet Earth** Origin of the Universe (Big Bang Theory), Origin of the Solar System (Nebular, Encounter and Tidal Hypothesis) a. Earth: Its size, shape and density. Temperature, pressure and magnetism within the Earth, Present day Hypsographic curve b. Age of the Earth: A brief account of the historical methods. Determination of age by U/Pb, Th/Pb, K/Ar and Carbon method of Dating. c. Meteorites (Definition, types and origin) **Geological time scale:** Concept and Criteria **Earth's Atmosphere:** (Introduction, Classification of Atmosphere, Introduction to Atmospheric circulation, land-air-sea interactions), Hydrosphere (Introduction to ocean currents, types, causes and significance), Lithosphere (Structure and composition) and Biosphere (Ecology and food chain)	**15**
II/15	**Dynamics of earth:** **Interior of Earth**: Earth's Crust, Mantle and Core **Plate Tectonics-** Historical Overview, Different types of plate movements with their salient characters, Various plates of the world and their movements **Volcanoes**: Genesis of volcanoes, Central and fissure type of eruptions. Products of volcanoes, effects of volcanoes, earth's volcanic belts. **Earthquakes**: Definition, terminology, causes, intensity and magnitude. Recording of earthquakes (Modern recording method). Use of seismic waves and their importance in interpreting the earth's internal structure.	**15**

	Seismic zones. History and susceptibility of the Indian subcontinent to earthquakes. **Types of Mountains**: Fold, fault block, volcanic and residual. **Geomorphic processes and landforms-** Weathering, erosion and denudation **Types of weathering:** Mechanical and Chemical Study of various erosional and depositional landforms resulting from the action of: River, Wind, Sea and Glaciers	

Suggested Readings:
References:

1. Holmes'Principles of Physical Geology: Edited by P. McL. D. Duff
2. Plate tectonics and Crustal evolution: Condie
3. Our evolving planet: Bergen, Alma Mater Fortag
4. Geomorphology and Global Tectonics: Summerfield M. A.
5. Geomorphology: Thornburry
6. Concepts of Geomorphology: Gupta and Kale

GL 141 VEC ENVIRONMENTAL GEOLOGY AN SUSTAINABILITY
(2 Credits)

Title of the Course and Course Code	**Environmental Geology and Sustainability GL 121 VSC**	**Credits:02**
Course Learning Outcomes (CLOs) On completion of the course, the students will be able to:		
CLO 1	Understand the fundamental concepts of environmental geoscience, its scope and necessity	
CLO 2	Know the fundamentals of earth science as applied to the interaction between human activity and the natural environment.	
CLO 3	Acquainted with different biogeochemical cycles like carbon, nitrogen, phosphorus and sulfur.	
CLO 4	Study in detail major societal burning issues including Water, Soil, and Air pollution.	
CLO 5	Students will be able to understand the Importance of Sustainability	
CLO 6	Relate environmental issues to the context of Sustainability	
CLO 7	Analyze the strategies for the Sustainable Development	

Unit/ Hour	**Course Contents**	**No of Lectures**
I/15	**Concept, Objective and Scope of Environmental Geology:** **A)** Seven concepts, Objectives, and Scope of Environmental Geology; Physical, Biological, and Socio-geological Environment, Bio-geochemical cycles. **B)** Deterioration of land surface: Dimensions of Erosion, processes, causes of accelerated erosion, remedial measures. **C)** Desertification and degradation of land: meaning, extent, causes and preventive measures. **D)** Ozone Depletion	**15**

	E) **Pollution:** a) **Water Pollution:** Water quality parameters, BIS standards Sources of water pollution (natural and man-made), Case histories related to water pollution: Minamata disease (Japan), Arsenic poisoning (West Bengal), and Flourosis (Bhandara) b) **Soil Pollution:** Sources of soil pollution (use of pesticides, fertilizers, industrial domestic water, and their effects c) **Air pollution:** Air Quality Index**,** Sources of air pollution, (aerosols, particulate matters in urban and industrial area), case histories: Chernobyl disaster and Bhopal gas disaster	
II/15	**Sustainability** 1. Sustainable Development: Definition, Scope and Emerging Trends. Environmental Scenario: Case study of India 2. Strategies for Sustainable Development: a) Conservation and development of natural resources, Crises faced by mankind with regards to conventional and non-conventional energy resources b) Soil conservation, badland topography, alkalinity and salinity of soils c) Water resources Management: Methods of Surface Rain Water Harvesting (Gabion Structure, Gully Plug, Check Dam ,Contour Bund , Percolation Tank , Mini-Hydel Plants) d) Solid waste disposal: Solid waste disposal methods (deep well disposal, ocean dumping, hazardous chemical wastes), its effects with geological perspective	**15**

Suggested Readings:
References:

1. Selby, M.J., (1996) Earths Changing Surface. Oxford University Press UK.
2. Thornbury W. D., (1997) Principles of Geomorphology Wiley Eastern Ltd., New Delhi.
3. Valdiya, K. S., (1987) Environmental Geology - Indian Context. Tata McGraw Hill New Delhi.
4. Keller, E. A., (2000) Environmental Geology. Shales E. Merril Publishing Co., Columbus, Ohio.
5. Montgomery, C., (1984) Environmental Geology. John Wiley and Sons, London.
6. Sharma J. P., Environmental Studies, Laxmi Publications (P) Ltd, New Delhi
7. Center for Science and Environment https://www.cseindia.org/

SEMESTER II

GL 151 MJ PETROLOGY I (2 Credits)

Title of the Course and Course Code	Petrology I GL 151 MJ	Credits:02
Course Learning Outcomes (COs) On completion of the course, the students will be able to:		
CLO 1	Understanding the processes of formation of different types of rocks (rock cycle).	
CLO 2	Students will be able to understand the process of evolution of magma & its types.	
CLO 3	Study of igneous forms (intrusive & extrusive).	
CLO 4	Study of textures, structures & classification of igneous rocks.	
CLO 5	Understanding the processes of formation of sedimentary rocks.	
CLO 6	Study of textures, structures, classification of sedimentary rocks & their environment of deposition.	
CLO 7	Understanding the concept of metamorphism, agents & its types.	
CLO 8	Study of textures, structures & classification of metamorphic rocks.	

Unit/ Hour	Contents	No of Lectures
I/15	**Introduction To Petrology And IgneousPetrology** **A] Introduction to Petrology** Definition of petrology, lithology, petrography, petrogenesis Types of rocks & their characteristics- Igneous, Sedimentary and Metamorphic Rock cycle **B] Introduction to Igneous Petrology** Magma and Lava, composition, physico-chemical constitution ofmagma, Bowen's reaction series and formation of crystals and glass Types of Magma: Primary and derivative, equilibrium betweencrystals and melt, crystallization of unicomponent Forms of Igneous bodies: Central and fissure type of eruptions Intrusive-Concordant-sill, laccolith, lopolith, phacolithDiscordant-dyke, volcanic neck and batholith (stock & boss) Extrusive-Lava flows, pyroclastic flows Textures and Structures Textures: Definition and factors controlling igneous textures Study of following textures & structures: granitic, graphic, porphyritic, poikilitic, ophitic, sub-ophitic, intergranular,intersertal, directive, glassy Structures: Vesicular, amygdaloidal, ropy, blocky, pillow, flow, columnar Tabular classification of igneous rocks on the basis of depth of formation, silica percentage, type of feldspar content and colour index	**15**
II/15	**Sedimentary Petrology** Sediments and derivation of sediments Source of sediments, mineral composition of clastic/detritalsediments Transportation of sediments- modes of transportation and progressive changes in sediments during transport	**15**

	Deposition of sediments- lithification, diagenesis and postdepositional changes, carbonates and other precipitates Textures and structures Textures- concept of matrix and cement, clastic and non-clastictextures Structures- Types of structures, Primary sedimentary structures- lamination, bedding, cross bedding, graded bedding, ripple marks and mud cracks **Metamorphic Petrology** Definition of metamorphism, protolith and their types, limits of metamorphism Agents of metamorphism Metamorphic minerals- Stress and anti-stress minerals Types of metamorphism & its products- Cataclastic,Thermal metamporphism,Regional metamorphism Textures and structures in metamorphic rocks	

Suggested Readings:
References:

1. Ernest Ehlers, Harvey Blatt, Petrology: Igneous, Sedimentary and Metamorphic, 1999, CBS Publishers
2. J. D. Winter, Principles of Igneous and Metamorphic Petrology, 2015, Pearson Publishers
3. Tyrrell, G.W., The Principles of Petrology: An Introduction to the Science of Rocks, 1949, Methurn Publisher
4. Dexter Perkins, 1998, Mineralogy, 3rd Edition, Pearson Education
5. Kevin Hefferan and John O'Brien, 2010 Earth Materials, A John Wiley & Sons, Ltd., Publication
6. S. M. Sengupta, Introduction to Sedimentology, 2018, 2nd Edition, CBS Publishers

GL 152 MJP PRACTICALS RELATED TO GL 151 MJ (2 Credits)

Title of the Course and Course Code	**Practicals related to GL 151 MJ GL 152 MJP**	**Credits:02**
Course Outcomes (COs) On completion of the course, the students will be able to:		
CLO 1	Identify different textures and structures in rocks.	
CLO 2	Classify various rocks using megascopic and microscopic properties.	
CLO 3	Examine different rocks in hand specimens.	
CLO 4	Distinguish different optical properties in minerals under microscope.	
CLO 5	Determine different minerals in micro-sections.	

Topics	No. of Practicals
Petrology Identification of the following **megascopic and microscopic** rocks with respect to their texture/structure, mineral composition, and classification a) Igneous: Granite, gabbro, rhyolite, basalt (its varieties), pegmatite (Classification based on colour index, mineral composition and texture)	3
b) Sedimentary: Laterite, bauxite, breccia, conglomerate, sandstone, shale, mudstone and limestone	3
c) Metamorphic: Slate, marble, quartzite, mica schist and mica gneiss, Augen Gneiss, banded haematite quartzite.	3
Description, genesis and significance of the following megascopic textures and structures Granitic, porphyritic, graphic, ropy, glassy, columnar, vesicular/ amygdaloidal	1
Description, genesis and significance of the following microscopic textures Granitic, Porphyritic, Poiklitic, ophitic and Sub-ophitic	1
Study of following Primary Sedimentary Structures in hand specimen with their Environmental Significance. 1. Bedding 2. Cross bedding 3. Graded bedding 4. Ripple marks 5. Mud/ Sun cracks	1
One day Geological Fieldwork to be conducted in an area of geological interest and geological report to be submitted for the same.	3
Total No. of Practicals	**15**

GL 161 OE INTRODUCTION TO ROCKS (2 Credits)

Title of the Course and Course Code	**Introduction to Rocks** **OE 161 GL**	**Credits:02**
Course Outcomes (COs) On completion of the course, the students will be able to:		
CLO 1	Understanding the formation of different types of rocks & their diagnostic characteristics.	
CLO 2	Study of structures of igneous rocks.	
CLO 3	Study of igneous rocks w.r.t their textures & structures.	
CLO 4	Understanding process of formation of sedimentary rocks.	
CLO 5	Study of sedimentary textures & structures of sedimentary rocks.	
CLO 6	Study of common sedimentary rocks.	
CLO 7	Understanding the process, agents & types of metamorphism.	
CLO 8	Study of textures & structures of metamorphic rocks.	
CLO 9	Study of common metamorphic rocks.	

Unit/ Hour	**Contents**	**No of Lectures**
I/15	Introduction to Rocks & their diagnostic characteristics: Igneous, sedimentary & Metamorphic Uses of the Rocks Classification of Rocks **Igneous Rocks:** Magma and Lava	15

	Central and fissure type of eruptions Intrusive forms: Concordant-sill, Discordant- dyke, batholith Extrusive forms: Lava flowsTextures and Structures Study of common igneous rocks	
II/15	**Sedimentary Rocks:** Sedimentary processesTextures and structures Study of common sedimentary rocks **Metamorphic Rocks:** Process of metamorphismAgents of metamorphism Types of metamorphism ,Textures and structures Study of common metamorphic rocks	15
Suggested Readings: **References:** Dexter Perkins, 1998, Mineralogy, 3rd Edition, Pearson Education Kevin Hefferan and John O'Brien, 2010, Earth Materials, A John Wiley & Sons, Ltd.,Publication G. B. Mahapatra, A Text Book of GEOLOGY, 1987, CBS Publishers and Distributors K. M. Bangar, 2015, Principles of Engineering Geology, 2nd Edition, StandardPublishers Distributors		

GL 162 OE: STUDY OF LANDFORMS (2 Credits)

Title of the Course and Course Code	**Study of Landforms GL 162 (OE)**	**Credits:02**
CLO1	Analyse geomorphological systems in terms of resisting and driving forces	
CLO2	Evaluate the creation of landforms by different surface processes	
CLO3	Describe the exogenous and endogenous processes in the landscape, their importance in landform development, and distinguish the mechanisms that control these processes	
CLO4	Analyse how variations in climate, tectonics and environment affect the development of landforms	

Unit/ Hour	**Contents**	**No of Lectures**
I/15	**Geomorphic processes and landforms** Weathering, erosion and denudation **Types of weathering:** **Mechanical** – frost wedging, frost action, insolation, activities of organic life and exfoliation **Chemical**-hydrolysis, hydration, solution, carbonation and oxidation The dynamics of erosional and depositional landforms resulting from the action of: **River** **Erosional landforms** – waterfall, potholes, mesa and butte, meandering and ox-bow lake, **Depositional landforms**- delta	15

	and types, alluvial fans, flood plains and river terraces. **Wind** **Erosional landforms** - deflation and deflation armour, yardangs, mushroom rock, **Depositional landforms** - sand dunes and its types, loess.	
II/15	**Sea** **Erosional landforms** - sea cliff, sea cave, natural arch, sea stack, **Depositional landforms**- Beach and longshore drift deposits **Glaciers** **Erosional landforms** - Valleys (U shaped and hanging valleys), crevasse, cirque, crag and tail **Depositional landforms** - moraines and its types, drumlins, eskers. **Karst Topography**	15

Recommended books for References:

1. Shuttleworth, E., Huggett, R. J. (2023). Fundamentals of Geomorphology. United Kingdom: Routledge.
2. Huggett, R. (2016). Fundamentals of Geomorphology. United Kingdom: Taylor & Francis.
3. Selby M.J. (1985), Earth's Changing Surface - An Introduction to Geomorphology, Oxford University Press
4. Gupta, A., Kale, V. S. (2001). Introduction to Geomorphology. India: Orient Longman. Summerfield, M. A. (2014). Global Geomorphology. United Kingdom: Taylor & Francis.
5. Bloom, A. L. (2004). Geomorphology: A Systematic Analysis of Late Cenozoic Landforms. United States: Waveland Press.
1. Physical Geography: Savindra Singh

GL171 SEC GEMMOLOGY (2 Credits)

Title of the Course and Course Code	**Gemmology** **SECP 151 GL**	**Credits:02**
Course Outcomes (COs) On completion of the course, the students will be able to:		
CLO 1	Understand the fundamentals of various precious and semiprecious gemstones	
CLO 2	Know their formation, classifications, basic qualities of gemstones, description of their various physical properties	
CLO 3	Learn about the different techniques involved in identification of natural and synthetic gemstones	
CLO 4	To learn Gem instruments and their use in gemstone identification	

Topics	**No. of Practicals**
1) Study of Physical properties of gemstones (Colour, Lustre, Diaphaneity, Sheen)	1
2) Study of different types of cuts used for gemstones	1

3) Description of following gem species with respect to their varieties (colour wise), Chemical composition, Crystal system, Physical and optical properties, Characteristic inclusions and Geographical Occurrences. Corundum, Beryl, Garnet, Felspar, Silica, Tourmaline, Topaz	4
4) Detection of double refraction, by observing pleochroic colours with the Dichroscope (at least 5) Garnet, Sapphire, Kyanite, Iolite, Paste, Emerald, Peridot	1
5) Study of the fluorescent colour exhibited by various gemstones under Ultraviolet (long wave and short wave) light (at least 5) Fluorite, Citrine,Natural Ruby, Synthetic Ruby, Almandine Garnet, Iolite, Natural Sapphire, Synthetic Sapphire	2
6) Study of Inclusions in Gemstones under microscope (at least 5) Sapphire, Ruby, Amber, Peridot, Rock Crystal, Amethyst, Topaz, Iolite, Citrine, Tourmaline, Kyanite, Paste, Almandine Garnet, Aquamarine	2
7) Study of Organic Gemstones: Pearl, Coral and Amber	1
8) Study of Opaque Gem varieties: Turquoise, Lapis Lazuli, Jade, Malachite	1
9) Study of Rare Gem varieties: Peridot, Kyanite, Iolite, Sphene, Zircon, Apatite	1
10) Study of Imitations and Synthetic Gemstones	1
Total No. of Practicals	**15**

GL 191 VEC OPTICAL MINERALOGY (2 Credits)

Title of the Course and Course Code	**Optical Mineralogy GL 191 (VSC)**	**Credits:02**
Course Outcomes (COs) On completion of the course, the students will be able to:		
CLO 1	Describe various properties and laws of light.	
CLO 2	Compare optical properties of minerals in Plane Polarised Light and in Between Crossed Nicols.	
CLO 3	Determine the refractive indices and optical sign of minerals.	
CLO 4	Explain interference figures.	
CLO 5	Compare uniaxial and biaxial minerals.	

Unit/ Hour	**Contents**	**No of Lectures**
I/15	Introduction: Light and the properties of light, Interference of light, Velocity of light in crystals and refractive index, Snell's Law and refraction of light, Polarized light and Crossed polars Petrological microscope Introduction to optical properties: Opaque and Non opaque Minerals **Properties in plane polarized light:** Color, form, cleavage, cracks, relief, twinkling, pleochroism and scheme of pleochroism Refractive indices and their comparison with Becke line	**15**

II/15	**Properties in between crossed nicols:** Isotropism and anisotropism, extinction positions and determination of extinction angle, twinning, zoning, and undulatory extinction,interference colors and Michel-Lévy color chart Introduction to Uniaxial and biaxial minerals Introduction to Interference figures of Uniaxial Minerals Accessory plates: mica plate, gypsum plate and quartz wedge **Preparation of Geological Thin Section**	**15**

Suggested Readings:

References:

2. Dexter Perkins, 1998, Mineralogy, 3rd Edition, Pearson Education
3. Kevin Hefferan and John O'Brien, Earth Materials, 2010, A John Wiley & Sons, Ltd., Publication
4. Gribble, C. D., 1988, Rutley's Elements of Mineralogy, 27th Edition, Unwin Hyman,London
5. Deer, W. A., Howie, R. A. and Zussman, J., 2013, An Introduction to Rock FormingMinerals, Essex: Longman Scientific and Technical; New York: Wiley., 696pp.
6. Kerr, B.F., (1995) Optical Mineralogy 5th Ed. McGraw Hill, New York