University of Pune

Two Year M. Sc. Degree Course in
GEOLOGY

M.Sc. Part I Syllabus
(To be implemented from Academic Year 2013-14)

Structure of syllabus: Basic structure/pattern (Framework) of the proposed postgraduate syllabus for the two year integrated course leading to M.Sc. (Geology) in the colleges affiliated to Pune University with medium of instructions being English.

1. Credit based Syllabus of M.Sc. Geology (Proposed from July 2013)

2. Preamble of the syllabus

i) Master's degree course in Geology would be of 100 credits, where one credit course of theory will be of one clock hour per week running for 15 weeks and one credit of practical course will consist of laboratory exercises of 15 clock hours.

ii) Student will have to take admission in Geology Department of the affiliated college and complete 75 credits incorporated in the syllabus structure of Geology. The remaining 25 credits shall be chosen from courses offered by the Geology Department or other Departments of the University and affiliated colleges with credit system structure.

iii) Four credits, one each in four semesters, have been allocated for Field work.

iv) Every student shall complete 100 credits in a minimum of four semesters. All Semesters will have 25 credits each.

v) Academic calendar showing dates of commencement and end of teaching, internal assessment tests and term end examination will be prepared and duly notified before commencement of each semester every year.

3. Terms and Conditions

The students seeking admission to M.Sc. Geology course are hereby informed that they are supposed to adhere to the following rules:

i) A minimum of 80 % attendance for lectures / practicals is the pre-requisite for Grant of Terms.

ii) There shall be 28 tutorial / practical tests as a part of internal assessment in each semester. The students are supposed to attend all the tests as per the timetable. The students should note that re-test will not be given to the student absent for the test/s.

iii) The students opting for dissertation course shall follow the rules framed for the same.

iv) To conduct optional theory credit courses minimum number of students required is **eight.**

v) Fieldwork is a compulsory component of the syllabus. The students are supposed to attend all the field tours / field cum-Laboratory Workshops organized by the department from time to time to cover credit Nos. GL-107, GL-207,GL-307 and GL-407 related to field components. The students shall attend the tours at their own cost and risk.

vi) The students are requested not to encourage friends to visit the department during working hours.

vii) The students are supposed to read the notices placed on various notice boards to keep the track of the academic and administrative activities.

4. Eligibility- The Candidate should have a B.Sc. degree with Geology as principal subject

OR

B.Sc. (General) degree with Geology as one of the subsidiary subjects.

5. Examination Rules

i. Assessment shall consist of a) In-semester continuous assessment and b) end semester assessment. Both shall have an equal weightage of 50% each**.**

ii. The teacher concerned shall announce the units for which each in-semester assessment will take place. However, the end-semester assessment shall cover the entire syllabus prescribed for the course.

iii. An in-semester assessment of 50% marks should be continuous and at least two tests should be conducted for full course of 4 credits and a teacher must select a variety of procedures for examination such as:
   a. Written Test and / or Mid Term Test (not more than one or two of each course)
   b. Term Paper
   c. Journal/Lecture/Library notes
   d. Seminar presentation
   e. Short quizzes
   f. Assignments
   g. Extension work
   h. An open book test (with the concerned teacher deciding what books are to be allow for this purpose)
   i. Mini Research Project by individual student or group of students

   The concern teacher in consultation with the Head of the PG Department shall decide the nature of questions for the Unit Test.

iv. Semester and examination for remaining 50% marks will be conducted by the University of Pune.

v. The student has to obtain 40% marks in the combined examination of In Semester assessment and Semester-End assessment with a minimum passing of 30% in both these separately.

vi. To pass the degree course, a student shall have to get minimum aggregate 40% marks (E and above on grade point scale) in each course.

vii. If a student misses an internal examination he/she will have a second chance with permission of the Principal in consultation with the concern teacher. Such a second chance shall not be the right of the student.

viii. Internal marks will not change. A student can not repeat Internal Assessment. In case he/she want to repeat internal assessment she/he can do so only by registering for the said courses during the 5^{th} / 6^{th} semester and onwards up to 8^{th} semester.

ix. Students who have failed semester-end exam may reappear for the semester-end examination only twice in subsequent period. The student will be finally declared as failed if she/he does not pass in all credits within a total period of four years. After that, such student will have to seek fresh admission as per the admission rules prevailing at that time.

x. A student cannot register for third semester, if she/ he fails to complete 50% credits of the total credits expected to be ordinarily completed within two semesters.

xi. There shall be Revaluation of the answer scripts of Semester-End examination but not of internal assessment papers as per Ordinance no. 134 A & B.

xii. While marks will be given for all examinations, they will be converted into grades. The semester end grade sheets will have only grades and final grade sheets and transcripts shall have grade points average and total percentage of marks (up to two decimal points). The final grade sheet also indicates the PG Centre to which the candidate belongs.

xiii. **Practical Courses**: Practical courses will be evaluated on the basis of each practical. For 2 credit practical course 15 practicals will be conducted, there will be two practical tests of 10 marks each and 5 marks will be given for attendance and journal completion.

xiv. **Field Work Components**: Four credits based on field work component, one in each semester, will constitute the compulsory part. There will be a continuous evaluation of the field work. The evaluation will be based on following four heads:

Heads	**Marks**	**Evaluating Authority**
Performance of the student in the field	5	by faculty members involved in conducting tour
Punctuality, enthusiasm, and aptitude of students while completing the report	5	by faculty
Tour report	10	By committee
Viva-voce	5	By committee

The final grade for fieldwork component – courses comprising of GL 107, GL 207, GL 307 and GL 407 will be awarded as a four credits course at the end of fourth semester.

6. Assessment of Grade point average:

Exam Rules:

i. The system of evaluation will be as follows: Each assignment / test will be evaluated in terms of grades. The grades for separate assignments and the final (semester-end) examination will be added together and then converted into a grade and later a grade point average. Result will be declared for each semester and the final examination will give total grades and grade point average.

ii. Marks/Grade/Grade Points

Marks	Grade	Grade Point
100 to 75	O : Outstanding	06
74 to 65	A : Very Good	05
64 to 55	B : Good	04
54 to 50	C : Average	03
49 to 45	D : Satisfactory	02
44 to 40	E : Pass	01
39 to 0	F : Fail	00

iii. Final Grade Point

Grade Point	Grade
05.00-06.00	O
04.50-04.99	A
03.50-04.49	B
02.50-03.49	C
01.50-02.49	D
00.50-01.49	E
00.00-00.49	F

iv. The formula for GPA will be based on Weighted Average. The final GPA will not be printed unless a student passes courses equivalent to minimum 100 credits, 80 credits or 64 credits as the case may be.

v. (i) Semester Grade Point Average(SGPA)=

$$SPGA = \frac{\sum_{i=1}^{p} Ci\ Gi}{\sum_{i=1}^{p} Ci}$$

$$SPGA = \frac{\sum \text{Grade Point Earned} \quad X \quad \text{Credits for each course}}{\text{Total Credits}}$$

(ii) Cumulative Grade Point Average (CGPA) =

$$CPGA = \frac{\sum_{i=1}^{p} Ci\ Gi}{\sum_{z=1}^{p} Ci}$$

$$CPGA = \frac{\sum \text{Total Point Earned} \quad X \quad \text{Credits for each course}}{\text{Total Credits}}$$

vi. 'B' Grade is equivalent to atleast 55% of the marks as per circular No. UGC-1298/ [4619] UNI-4 Dated December 11,1999.

vii. A seven point grade system [guided by the Government of Maharashtra Resolution No. NGV-1298/[4619]UNI-4 Dated December 11,1999 and the University regulations] will he followed uniformly for Science, Arts, Mental, Moral and Social Sciences. The corresponding grade table is detailed in II. 14 above.

viii. If the GPA is higher than the indicated upper limit in the three decimal digit, then the student be awarded higher final grade (e.g. a student getting GPA of 4.492 may be awarded 'A'.

ix. There will be only final compilation and moderation at GPA (Final) level done at the Department. While declaring the result, the exiting relevant ordinances are applicable. There is also a provision for verification and revaluation In case of verification, the existing rules will be applicable. The revaluation result will adopted if there is a change of at least 10% marks and in the grade of the course.

x. For grade improvement a student must reappear for semester-end examination for a minimum 30 credits in case of Science , 20 credits in case of faculties other than Sciences and 12 credits in case of one year degree programmes. These courses will be from will be from parent department. Grade Improvement programme will be implemented at the end of the academic year. A student can opt for the grade improvement programme only after the declaration of final semester (i.e. at the end of the next academic year after passing the M.A./ M.Sc. examination and within two years of completion of M.A./ M.Sc. and only once.

xi. The description for each of the grades will be as follows.

Grades Proposed Norms

O: Outstanding : Excellent analysis of the topic, (75% and above)
Accurate knowledge of the primary material, wide range of reading logical development of ideas, originality in approaching the subject, Neat and systematic organization of content, elegent and lucidstyl;
A: Very Good : Excellent analysis of the topic, (65% and 74%)
Accurate knowledge of the primary material, acquaintance with seminal publications, logical development of ideas, neat and systematic organization of content, effective and clear expression;
B: Good: Good Analysis and treatment of the topic (55 to 64%)
Basic knowledge of the primary material, logical development of ideas, neat and systematic organization of content, effective and clear expression;
C: Average: Some important points covered (50 to 54%)
Basic knowledge of the primary material, logical development of ideas, neat and systematic organization of content, effective and clear expression;
D: Satisfactory : Some points discussed (45 to 49%)
Basic knowledge of the primary material, some organization, acceptable language or expression;
E: Pass: Any two of the above (40 to 44%)
F: Fail: None of the above (0 to 39%)

7 External Students: External students are not admitted for this course.

8 Setting of question paper/ Pattern of question paper:

Paper setting and assessment for a particular course would be the responsibility of the course In-charge, and these activities would be coordinated by the Department Examination Committee. The Department Examination committee would undertake preparation of the result-sheets for the students.

The question paper of 50 marks will consist of seven questions, out of which students will solve five questions. Two questions, one long answer question and one short note question will be compulsory.

9 M.Sc. Geology - Course structure & Credit Distribution.

Semester I (All courses compulsory)

GL 101: Mineralogy (4 Credits)
GL 102: Principles of Stratigraphy and Paleontology (4 Credits)
GL 103: Physics and Chemistry of the Earth (4 Credits)
GL 104: Sedimentology (4 Credits)
GL 105: Practicals related to courses GL 101 & GL 102 (4 Credits)
GL 106: Practicals related to courses GL 103 & GL 104 (4 Credits)
GL 107: Fieldwork component (1 credit)

Semester II (All courses compulsory)

GL 201: Igneous Petrology (4 Credits)
GL 202: Metamorphic Petrology (4 Credits)
GL 203: Structural Geology and Tectonics (4 Credits)
GL 204: Geomorphology and Remote Sensing in Geology (4 Credits)
GL 205: Practicals related to courses GL 201 & GL 202 (4 Credits)
GL 206: Practicals related to courses GL 203 & GL 204 (4 Credits)
GL 207: Fieldwork component (1 credit)

Semester III

GL 301: Indian Stratigraphy (4 Credits) Compulsory
GL 302: Exploration Methods (4 Credits)
GL 303: Petroleum Geology (4 Credits)
GL 304: Engineering Geology and Geotechniques (4 Credits)
GL 305: Practicals related to GL 301-4 credits & combination of theory Courses totaling to 8 credits (4 credits) Compulsory
GL 306: Practicals related to combination of remaining theory courses totaling to 8 credits (4 credits) Compulsory
GL 307: Fieldwork component (1 credit) Compulsory
GL-308: Geostatistics and Computer Applications in Geology (2 Credits)
GL 309: Marine Geology and Oceanography (4Credits)
GL-310: Natural Resource Management (2 Credits)
GL-311: Oil field Services (2 Credits)

Semester IV

GL 401: Economic Geology (4 Credits)
GL 402: Mining Geology and Gemmology (4 Credits)
GL 403: Environmental Geology (4 Credits)
GL 404: Hydrogeology, Watershed Development and Management (4 Credits)
GL 405: Practicals related to combination of Theory Courses totaling to 8 credits (4 credits) Compulsory

GL 406: Practicals related to combination of remaining theory courses totaling to 8 credits (4 credits) Compulsory
GL 407: Fieldwork component (1 credit) Compulsory
GL 408: Dissertation (4 Credits)
GL-409: Application of GIS in Geology (2 Credits)
GL 410: Applied Micropalaeontology (2 Credits)
GL 411: Sequence Stratigraphy (2 Credits)

Medium of Instruction is ENGLISH

10 Equivalence of previous syllabus along with proposed syllabus.

EQUIVALENCE

Semester	Present Course		Proposed Course	
	Course Code	**Course Name**	**Course Code**	**Course Name**
I	GL-101	Mineralogy	GL-101	Mineralogy
	GL-102	Principles Of Stratigraphy And Paleontology	GL-102	Principles Of Stratigraphy And Paleontology
	GL-103	Physics And Chemistry Of The Earth	GL-103	Physics And Chemistry Of The Earth
	GL-104	Sedimentology	GL-104	Sedimentology
	GL-105	Practicals Related To Above Courses	GL-105 & GL-106	Practicals Related To Above Courses
II	GL-201	Ingeous Petrology	GL-201	Ingeous Petrology
	GL-202	Metamorphic Petrology	GL-202	Metamorphic Petrology
	GL-203	Structural Geology And Tectonics	GL-203	Structural Geology And Tectonics
	GL-204	Geomorphology And Remote Sensing In Geology	GL-204	Geomorphology And Remote Sensing In Geology
	GL-205	Practicals Related To Above Courses	GL-205 & GL-206	Practicals Related To Above Courses
III	GL-301	Indian Stratigraphy - Compulsory (Departmental)	GL-301	Indian Stratigraphy
	GL-302	Exploration Methods	GL-302	Exploration Methods
	GL-303	Petroleum Geology	GL-303	Petroleum Geology
	GL-304	Engineering Geology And Geotechniques	GL-304	Engineering Geology And Geotechniques
	GL-305	Computer Application In Geology And GIS	GL-308 GL-409	Geostatistics and Computer Applications in Geology (2 Credits) Application of GIS In Geology(2 Credits)

	GL-306	Natural Resource Management & Oil Field Services	GL-310 GL-311	Natural Resource Management(2 Credits) Oil Field Services (2 Credits)
	GL-307	Practicals Related To Above Courses - Compulsory (Departmental)	GL-305 GL-306	Practicals related to GL 301-4 credits & combination of theory Courses totaling to 4 credits (4 credits) Practicals related to combination of remaining theory courses totaling to 8 credits (4 credits)
IV	GL-401	Economic Geology	GL-401	Economic Geology
	GL-402	Mining Geology, Gemmology And Industrial Mineralogy	GL-402	Mining Geology And Gemmology
	GL-403	Environmental Geology	GL-403	Environmental Geology
	GL-404	Hydrogeology, Watershed development And Management	GL-404	Hydrogeology, Watershed development And Management
	GL-405	Dissertation	GL-408	Dissertation
	GL- 406	Fieldwork Component- Compulsory (Departmental)	GL-107 GL-207 GL-307 GL-407	Fieldwork Component Fieldwork Component Fieldwork Component Fieldwork Component
	GL-407	Practicals Related To Above Courses Compulsory (Departmental)	GL-405 GL-406	Practicals related to combination of Theory Courses totaling to 8 credits (4 credits) Practicals related to combination of remaining theory courses totaling to 8 credits (4 credits)

11 University Terms- Date of commencement and end of teaching will be notified before the commencement of each semester every year.

12 Qualification of Teacher- Candidate with M.Sc. (Geology) degree with NET/SET qualification. Other criteria as per the guidelines of UGC and University of Pune.

10. Course wise Syllabus and recommended books:-

SEMESTER –I

GL 101: MINERALOGY (4 credits)

UNITS	TOPICS	NO.OF LECTURES

UNIT- 1 **Crystallography** **15**

- Definition of Crystal – Classification of crystal into Crystal Systems
- Concept of unit cell – Proper and improper symmetry operations
- Concept of Point Group – Classification of crystals into 32 Point Groups
- Concept of Space lattice – Derivation of 14 Bravais lattices – HCP
- Concept of Space Group – Symmorphic and Asymmorphic Space Groups
- Mineralogical investigations methods -X- ray diffraction, Electron Probe Micro Analysis (EPMA), Scanning Electron Microscope (SEM), and Raman Spectroscopy.
- Mineral Chemistry – Concepts and examples of Isomorphism, solid solutions
- Mantle Minerals –Pyroxene (Diopside, Enstatite) Olivine, Spinel, Garnet, Perovskite.

UNIT- 2 **Mineral Optics** **15**

- Plane polarized and cross polarized light – Isotropic and Anisotropic minerals, Behaviour of minerals in cross polarized light
- Birefringence – Uniaxial minerals – Uniaxial and Biaxial Indicatrices – Orientation of indicatrices as per the section
- Interference of light waves – Passage of light through doubly refracting minerals, Generation of interference colours
- Conoscopic or convergent polarized light – Generation of Uniaxial and Biaxial interference figures – Forms of interference figures related to sections – Optical accessories like mica, gypsum and quartz plates – determination of Optic sign of uniaxial and biaxial minerals.
- Absorption of light by minerals – Scheme of pleochroism

UNIT- 3 **Descriptive Mineralogy -I** **15**

- Structure, relation of Chemical composition with optical, physical properties, alteration products and paragenesis of following group of minerals.

  Olivine, Pyroxenes, Amphiboles, Garnet, Mica, Alumino silicates, Epidote

UNIT- 4 **Descriptive Mineralogy –II** **15**

- Structure, relation of Chemical composition with optical, physical properties, alteration products and paragenesis of following group of minerals.
  Feldspar, Feldspathoid, Zeolite and Clays

Total number of Lectures **60**

GL 102: PRINCIPLES OF STRATIGRAPHY AND PALAEONTOLOGY

(4 credits)

UNIT-1 **Principles of Statigraphy** **(2 credits)** **30**

- History and Development of Statigraphy
- Stratigraphic procedures (Surface and Subsurface)
- Concept of Lithofacies and Biofacies
- Stratigraphic Correlation (Litho, Bio- and Chronostrarigraphic Correlation)
- Study of standard stratigraphic code (Lithostratigraphic, Biostratigraphic and Chronostratigraphic)
- Concepts of Magnetostratigraphy, Chemostratigraphy, Event stratigraphy, and Sequence stratigraphy

UNIT-2 **Palaeontology** **(2 credits)** **30**

- Techniques in Palaeontology - mega fossils- microfossils – nannofossils - ichnofossils – collection, identification and illustration – binomial nomenclature
- Invertebrate Palaeontology – A brief study of morphology, classification, evolutionary trends and distribution of Bivalves, Cephalopods, Gastropods, Echinoids, Corals and Brachiopods.
- Vertebrate Palaeontology – Brief study of vertebrate life through ages. Evolution of reptiles and mammals.
- Palaeontological perspective : Use of palaeontological data in a) Stratigraphy b) Palaeoecology and evolution
- Introduction to Micropalaeontology
- Types of Microfossils
- Palaeopalynology
- Foraminifera and Ostracods

60

Total number of Lectures

GL 103 : PHYSICS AND CHEMISTRY OF THE EARTH (4 credits)

UNIT-1 Astronomy & Astrophysics **15**

- Big Bang Theory
- Components of the Universe; Planets: Kepler's laws, retrograde motion, Asteroids, Comets, Galaxies: types and classification, Stars and star formation processes, Stars life cycle
- EM Spectrum: radiation from heated objects, Wien's law, radiation curves, Doppler Effect. Optical and Non-optical astronomy.
- Meteorites and their classification
- Origin and components of solar system
- Abundance of elements
- Nucleosynthesis and stellar evolution
- Orbital dynamics of earth-moon system

UNIT-2 Seismology and Interior of the Earth **15**

- Seismic waves and their velocities
- Internal structure of earth
- Structure composition and evolution of the crust, mantle and core
- Geochemical classification and distribution of elements in the earth
- Structure and atomic properties of elements
- The Periodic table
- Laws of Thermodynamics and phase diagrams

UNIT-3 <u>Geochronology and age of the Earth</u> **15**

- Law of Radioactivity
- Principles of isotopic dating, Decay schemes and Derivation of equation of age.
- Rb-Sr, U- Th –Pb , K –Ar, C-14 methods of dating the rocks.
- Age of the Earth

UNIT-4 <u>Gravity, Magnetism and Thermal History of the Earth</u> **15**

- Density distribution, shape and mass of the earth, density vs depth profile**.**
- Gravity and gravitational mechanics, gravity anomalies and their interpretation
- The earth as Magnet, Earth's magnetic field, changes in magnetic field, origin of geomagnetic field, palaeomagnetism
- Heat-flow measurements.

- Temperature in Primitive Earth and Core of the Earth.
- Heat-flow and Radioactivity, The thermal history of Earth.

Total number of Lectures **60**

GL – 104 : SEDIMENTOLOGY (4 credits)

UNIT-1 **Procedures** **15**

- Field procedures in Sedimentary Petrology- stain analysis – methodology and significance
- Geologic cycle - Introduction
- Sedimentary textures (Granulometric analysis, shape and roundness studies, surface textures)
- Heavy mineral and Insoluble residue analysis – Procedure and their significance

UNIT-2 **Petrography** **15**

- Petrography of rocks of clastic, chemical and biochemical origin (Conglomerates, Sandstone, Mudstone, Limestone and Dolomite)
- Evaporite, Phosphorite, Chert, Iron and Manganese rich sediments
- Volcanogenic sedimentary rocks
- Significance of Petrographic Analysis

UNIT-3 **Hydraulic and Structure** **15**

- Classic transport and fluid flow (fluid flow in theory and in nature, Reynold's Numbers, Froude Number, Sediment lift, transport, deposition, Sedimentary gravity flow)
- Sedimentary structures (Physical structures, Biogenic sedimentary Structures, Diagenetic structures)

UNIT-4 **Environment and Facies** **15**

- Concept of Sedimentary facies association models (Marine, Nonmarine and Mixed Depositional Environment)
- Sedimentation and Tectonics
- Paleocurrents and Basin Analysis

Total number of Lectures **60**

GL 105: Practicals related to courses GL 101 & GL 102 (4 Credits)

Unit 1: Practicals for GL 101:

1. Study of interference figures – determination of optical sign of minerals.
2. Determination of composition of plagioclase feldspars by Michel Levy method .

3. Construction of Stereograms and Gnomonograms for Cubic ,Tetragonal and Orthorhombic system.
4. Study of rock forming minerals in thin sections
5. Study of rock forming minerals in hand specimens
6. Calculation of mineral formulae based on weight percentage

Unit 2: <u>Practicals for GL 102</u>:

1. Construction of rank charts for lithostratigraphy, biostratigraphy & chronostratigraphy.
2. Construction of graphical logs for text descriptions.
3. Exercises in correlation from given data or logs.
4. Construction of range charts
5. Study of morphology of Bivalves, Gastropods, Cephalopods, Echinoids, Brachiopods.
6. Separation, processing, wet sieve analyses, preparation of slides of microfossils.
7. Morphology and morphological descriptions of planktonic & benthonic foraminifera, Ostracodes.
8. Morphology of Radiolaria , Diatoms, pollen and spores

GL 106: Practicals related to courses GL 103 & GL 104 (4 Credits)

Unit 1: <u>Practicals for GL 103</u>:

1. To determine temperature of stars from λ max.
2. To calculate velocity of recession from Red shift.
3. To identify spectra of various stars.
4. Rapid analyses of rocks for determination of major oxides by volumetric /gravimetric/colorimetric methods.
5. Introduction to the use of instrumental technique of analyses of rocks, soil & water.
    - Spectrophotometry
    - Flame photometry
    - Atomic Absorption Spectrophotometry (Demonstration only)
    - High Performance Ion Chromatography (Demonstration only)
    - Plotting of chemical data on variation diagrams.
6. Problems related to seismic, geomagnetic, gravity data & its interpretation.
7. Problems related to use of isotopic methods & determinations of age of the rocks.

Unit 2: <u>Practicals for GL- 104</u>:

1. Size Analysis (Procedures, Cumulative curve, Histogram, Visher's curve and Statistical calculation)
2. Shape analysis (Calculation and Classification)
3. Heavy mineral analysis (Procedure and identification)
4 Preparation of thin section of Heavy Mineral.
5 Megascopic studies of conglomerate and breccia
6 Megascopic and microscopic study of sandstone.
7 Megascopic and microscopic study of limestone

8 Sedimentary structure (Identification and classification)
9 Paleocurrent and basin analysis calculation
10 Study of vertical profile section of some selected sedimentary environments

GL-107:- Fieldwork Component (1credit)

Text books for Semester –I

- Dana: Elements of Mineralogy
- Winchell: Elements of Optical Mineralogy
- Kerr: Optical Mineralogy
- Whalstrom: Optical Crystallography
- Deer, Howie Zussman: Rock forming minerals, Vol. I – IV
- Cracknell: Crystals and their structure
- Frye Keith: Modern Mineralogy
- Read: Beginners Guide to Gemmology
- Webster Anderson: Gems
- Anderson B.W. Gem Testing
- Webster R. : Practical Gemmology
- Bates : Geology of Industrial Rocks and Minerals
- Roy: Indian Mineral Resources
- Baungart, Dunham and Amstutz : Process Mineralogy of Ceramic Materials
- Krumbein and Sloss: Stratigraphy and Sedimentation
- Dunbar and Rogers: Principles of stratigraphy
- Hedberg: International Stratigraphy guide
- Harland et., al.: A geological time scale
- Lemon Roy R.: Principles of Stratigraphy
- Weller: Stratigraphic principles and practice
- Brenner and Mc Hargue: Integrative Stratigraphy
- Boardman R.S., Cheetham A.H., Rowell A.J.: Fossil invertebrates
- Clarkston E.N.K.: Invertebrate Palaeontology and Evolution
- John R. Haynes, Hohn Wiley and Sons : Foraminifera
- M.D. Brasier: Microfossils
- Swinnerton; Outline of Palaeontology
- Moore Lalicker and Figher: Invertebrate Palaeontology
- Remer: Vertebrate Palaeontology
- Shrock and Twenhofel : Principles of invertebrate Palaeontology
- Arnold : Introduction to Palaeobotany
- Bignot G: Elements of Micropalaeontology. The microfossils, their Geological and Palaeobiological applications
- Clobert E.H.: Evolution of the Vertebrates
- Brown and Mussett: The inaccessible Earth
- Jackson (ed.): The Earths Mantle
- Stacy: Physics of the Earth
- Melchior: The physics of the Earths Core: An Introduction

- Jacobs, Russels and Wilson: Physics and Geology
- Sheidegger: Principles of Geodynamics
- Van Bemmelen: Developments in Geotectonics No.2 (Geodynamics Model: An evaluation and synthesis)
- Jeffreys: The Earth: Its origin, History and Physical constitution
- Kauls: An Introduction to Planetary Physics
- Takanaki and Kanamori: Debate about the Earth
- Pettijohn: Sedimentary Rocks
- Blatt, Middleton and Murry: Origin of Sedimentary Rocks
- Reineck and Singh: Sedimentary Depositional Environments
- Carozzi: Patrography of Sedimentary Rocks
- Carver: Procedures in Sedimentary petrology
- Potter and Pettijohn: Palaeocurrents and Basin analysis
- Astronomy structure of the Universe. A.E. Roy and D. Clarke, adam Hilger Pub.
- Source Book of Space Sciences, Samuel Galsstone; D.Van Nostrand Co. Inc
- Astrophysics - Stars and Galaxiesl, K.D. Abhyankar, Tata McGraw Hill Pub.
- Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Pub.
- Structure of the Universe, J.V. Narlikar
- Astrophysics, Badyanath Basu.
- Physics of the Earth: Frank D Stacey Paul M Davis

SEMESTER- II

GL-201: IGNEOUS PETROLOGY (**4 credits**)

UNITS: **TOPICS** **No. of Lectures**

Unit 1: <u>Role of magma in Geological processes</u> **15**

- Magma definition and source of magma
- Anatomy of the earth
- Geochemical and Geophysical jargon
- Magmatism and plate tectonics
- Physical properties of magma-Geochemical gradient,
- Heat source
- Igneous activity of the present day
- Textures and structures of Igneous rocks
- Classification of Igneous rocks-historic perspective and the IUGS system.

Unit 2: <u>Geochemical tracers of mantle processes</u> **15**

- Introduction
- Continental & oceanic mantle lithosphere
- MORB and depleted mantle
- Evolution of depleted mantle
- OIB and Enriched mantle
- Evolution of Enriched mantle – metasomatic processes

- Island arc basalts
- Concept of hot spots
- Mantle Plumes-Theory and structure
- Re-Os Isotope systematics
- Trace element characterizations of mantle domains

Unit 3: Magma Crystallization and Evolution **15**

- Phase relations of the silicates and silicate melts
- Binary and Ternary systems
- Partial melting,
- Magmatic differentiation – Crystal fractionation, gravitational settling, flow differentiation, flow crystallisation, filter pressing, liquid immiscibility.
- Zone melting
- Contamination
- Mixing of magmas
- Role of volatile components

Unit 4: Petrogenetic provinces **15**

- Continental areas: Volcanic- Flood basalts- Tholeiites (Deccan Trap, Columbia River basalts, Parana basalts)
- Layered gabbroic intrusions: The Bushveld Complex, Skaergaard intrusion, Still Water Complex.
- Plutonic: Carbonatites and alkaline rock complexes of India
- Oceanic Rift valleys: MORB- Tholeiites-Ophiolites
- Granites, andesites, kimberlites, anorthosites.

Total No. of Lectures **60**

GL-202: METAMORPHIC PETROLOGY (**4 credits**)

Unit 1: Concepts and Theory **15**

- Historical background
- Types of Metamorphism and their controlling factors
- Common minerals of metamorphic rocks
- Field observations, petrographic classification of common metamorphic rocks
- Metamorphic facies and facies series

Unit 2: Effects of Metamorphism **15**

- Phase diagrams and graphic representation of mineral assemblages
- Prograde and retrograde metamorphism, Metasomatism
- Deformation textures and textures related to recrystallisation
- Metamorphic reactions, elemental exchange and Pressure – Temperature conditions of Isograds

Unit 3: Metamorphism: Types and Products **15**

- Regional and thermal metamorphism of pelitic rocks.
- Regional and thermal metamorphism of basic and ultrabasic rocks
- Regional and thermal metamorphism of impure,silicious carbonate rocks
- Metamorphism of Granitoids; Charnockites and Migmatites

Unit 4: Metamorphism in space and time **15**

- Plate tectonics and metamorphic processes
- Paired metamorphic belts, Archaean and Proterozoic terrains
- Extraterrestrial Metamorphism (Impact and Shock Metamorphism), polymetamorphism

Total No. of Lectures **60**

GL-203: STRUCTURAL GEOLOGY AND TECTONICS (**4 credits**)

Unit 1: Deformation and Structures in Rocks **15**

- Theories of rock failure; Mechanical principles, properties of rocks and their controlling factors; Concept of stress and strain: Classes of stress; stress ellipsoid; Mohr circle; Stress-strain relationship; Strain parameters, Strain Analysis: progressive deformation, significance of geological structures in relation to strain, pore pressure, failure of rocks due to differential stress
- Description of folds; Mechanisms of folding (buckling, bending and flow), Superimposed folding, Type 1, 2, 3 fold interference patterns; Geometric and genetic classification of folds, Geometry of boudinage structure and its significance

Unit 2: Structures in Rocks **15**

- Mechanism of rock fracturing; Development of cleavage, lineation, foliation and schistosity in rocks and their mechanism
- Faults: Causes, mechanism and dynamics of faulting, strike-slip faults, normal faults, thrust faults and nappe
- Shear Zones: Brittle and ductile shear zones, geometry and products of shear zones; Mylonites and cataclasites: their origin and significance.
- Fractures and joints: their classification, nomenclature, relationships and significance; Joints in relation to stresses and their geometrical relationship with folds and faults.

Unit 3: Structural Analysis **15**

- Scope of structural analysis,
- Concept of Tectonite fabric/ petrofabric and their symmetry, Types of fabric (planar and linear fabrics in deformed rocks), fabric element, and interpretation of fabric data on microscopic and megascopic scale; Field and laboratory techniques, graphical treatment.
- Stereographic projections of linear and planar structures, π and β diagrams; Geometrical analysis of simple and complex structures on macroscopic scale

Unit 4: Tectonics **15**

- Structure and physical characters of continental and oceanic crust
- Continental drift, seafloor spreading and Plate Tectonics, Structure and Tectonics of divergent margins, transform faults, convergent margins
- Tectonic framework of India
- Neotectonics – Features and evidences – Characteristic landforms, methods of analysis

- Case studies of Orogenic belts

Total No. of Lectures 60

GL204: GEOMORPHOLOGY AND REMOTE SENSING IN GEOLOGY (4 credits)

Unit 1: Geomorphology 30

- Introduction : Development, Scope, Geomorphic concepts, Types and Tools
- Landforms: Role of Lithology, peneplaination, Endogenous and Exogenous forces, Climatic and Tectonic factors and Rejuvenation of landforms
- Denudational processes : Weathering , erosion, transportation, weathering products and soils – profiles, types, duricrusts
- Hill slopes : Their characteristics and development, fluvial processes on hill slopes
- River and drainage basin: Drainage pattern, network characteristics, Valleys and their development, processes of river erosion, transportation and deposition
- Landforms produced by geomorphic agents: Fluvial, Coastal , Glacial and Aeolian landforms
- Geomorphic indicators of neotectonic movements : Stream channel morphology changes , drainage modifications, fault reactivation, Uplift – subsidence pattern in coastal areas
- Applied Geomorphology : Application in Geohydrology, Engineering Geology and Environmental studies
- Geomorphology of India: Geomorphical features and zones

Unit 2: Remote Sensing 30

- Electromagnetic radiation – types and sources
- Interaction of EMR with earth, reflectance – absorption – emittance and transmittance
- Black, white and grey bodies
- Different methods of Remote Sensing based on atmospheric windows
- Aerial photographs – classification, types
- Principles of photogrammetry
- Calculations of heights and slopes from aerial photographs
- Aerial photointerpretation – photo recognition elements of black and white aerial photographs
- Interpretation of different geological features on B/W aerial photographs
- Remote sensing from space – space crafts and sensors
- Landsat, Skylab, Seasat and other foreign systems of satellites and their interpretation for geological and other studies
- Image analysis
- Space research in India – Bhaskara and IRS systems and their applications,Thermal IR remote sensing and its applications, Microwave remote sensing and its applications

Total No. of Lectures **60**

GL 205: Practicals related to courses GL 201 & GL 202 (4 Credits)

Unit 1: <u>Practicals for GL-201</u>

- Characterisation of Igneous rocks, textures and structures
- Characterisation of following rock types under microscope
    a. Ultrabasic rocks
    b. Basic Igneous rocks
    c. Intermediate Igneous rocks
    d. Acid Igneous rocks
    e. Alkaline Igneous rocks
- CIPW normative calculations for Igneous rocks
- Use of trace elements in petrogenesis

Unit 2: <u>Practicals for GL-202</u>

- Study of metamorphic rocks in hand specimens and thin sections : Metamorphic mineral assemblages with respect to metamorphic facies and grades
- Use of ACF, AKF and AFM diagrams
- Use of rock composition diagrams
- Calculation of Pressure – Temperature conditions from the composition of co-existing mineral assemblages serving as geothermometers and geobarometers

GL 206: Practicals related to courses GL 203 & GL 204 (4 Credits)

Unit 1: <u>Practicals for GL-203</u>

- Solution to structural geology problem by orthographic and stereographic methods
- Completion of outcrops, construction of structural sections and interpretation of geological maps
- Plotting and interpretation of mesoscopic structural data

Unit 2: <u>Practicals for GL-204</u>

- Determination of photo scale
- Determination of height of objects, dip of beds , slope and thickness of beds by parallax bar
- Study of landforms and interpretation of lithology and structure from aerial photographs and satellite images
    - Tracing of lineaments and rosettes and their interpretation
    - Drainage basin and network morphometry
    - Relief and slope analyses – profiles and maps
    - Identification of landforms on toposheets, aerial photographs and satellite images

GL-207:- Fieldwork Component (1 credit)

Text Books for Semester – II

- Barker – Igneous rock
- Magmatic rocks – Middle most
- Igneous rocks – Rock
- Philpot – Igneous and Metamorphic Petrology
- Jackson (ed) –Earth's Mantle
- Davis – Earth Dynamics
- Yoder - Basalt
- Yoder& Tilly – Basaltic Magnetism
- Jackson Lan (ed) –The Earth's Mantle : Composition , Structure and Evolution
- Davis G.F. – Dynamic Earth : Plates , Plumes and Mantle Conviction
- Turner & Varhoogen : Igneous and Metamorphic Petrology
- Philpotts : Principles of Igneous and Metamorphic Petrology
- Harker : Metamorphism
- Turner : Metamorphic Petrology
- Wrinkler : Petrogeneous of Metamorphic Rock
- Miyashiro : Metamorphism and Metomorphic Belts
- Yardly : An Introduction to Metamorphic Petrology
- Spry: Metamorphic Structures
- Best: Igneous and Metamorphic Petrology
- Patwardhan : The Dynamic Earth System
- E.M.Moores & R.J. Twiss : Tectonics
- Valdiya : Aspects of Tectonics – Focus on South Central Asia
- V.V. Beloussov: Geotectonics
- Condie : Plate Tectonics and Crystal Evolution
- Billings : Structural Geology
- Badgley : Structural and Tectonics Principles
- Turner & Weiss: Analysis of Metamorphic Tectonic
- Ramsay : Folding and Fracturing of Rock
- Desittar : Structural Geology
- Sander: Introduction to Deformation of Geologic bodies
- Miller & Miller : Photogeology
- Ramsay : Trends in Geological Remote Sensing
- Lillysand & Kaifer : Remote Sensing and Image interpretation
- Pandey : Photogeology
- Thombury : Principles of Geomorphology
- Rice : Fundamentals of Geomorphology
- Kale & Gupta : Introduction to Geomorphology
- A.D. Howward and I Remson : Geology in Environmental Planning