KAVAYITRI BAHINABAI CHAUDHARI NORTH MAHARASHTRA UNIVERSITY, JALGAON

॥अंतरी पेटवू ज्ञानज्योत॥

'A' Grade
NAAC Re-Accredited
(3rd Cycle)

SYLLABUS

for

Master of Science (M. Sc.)
Applied Geology

Choice Based Credit System
(Outcome Based Curriculum)

DEPARTMENT OF APPLIED GEOLOGY,

SCHOOL OF ENVIRONMENTAL AND EARTH SCIENCES

KAVAYITRI BAHINABAI CHAUDHARI NORTH MAHARASHTRA UNIVERSITY,

JALGAON 425 001 (M.S.)

(2019 – 2020)

Summary of Distribution of Credits under CBCS Scheme
for
M.Sc. Applied Geology
at
School of Environmental and Earth Sciences
[at University Campus under Academic Flexibility w.e.f. 2019-20]

Sr. No.	Type of course	Sem I	Sem II	Sem III	Sem IV
01	Core	**16**	**16**	**16**	**12**
02	Skill based	**04**	**04**	**-**	**-**
03	School Elective	**-**	**-**	**04**	**04**
04	Project	**-**	**-**	**-**	**04**
05	Audit	**02**	**02**	**02**	**02**
06	Total Credits	**22**	**22**	**22**	**22**

Subject Type	Core	Skill based	School Elective	Project	Audit	Total
Credits	**60**	**08**	**08**	**04**	**08**	**88**

Total Credits = 88

SCHOOL OF ENVIRONMENTAL AND EARTH SCIENCES

KAVAYITRI BAHINABAI CHAUDHARI NORTH MAHARASHTRA UNIVERSITY, JALGAON

Syllabus under CBCS for M.Sc. (Applied Geology)

Choice Based Credit System (Outcome Based Curriculum) with effect from 2019 -2020

Course credit scheme

Semester	(A) Core Courses			(B) Skill Based / Elective Course			(C) Audit Course (No Weightage in CGPA)			Total Credits (A+B+C)
	No. of Courses	Credits (T+P)	Total Credits	No. of Courses	Credits (T+P)	Total Credits	No. of Courses	Credits (Practicals)	Total Credits	
I	4	8 + 8	**16**	1	4 + 0	4	1	2	2	**22**
II	4	8 +8	**16**	1	4 + 0	4	1	2	2	**22**
III	4	8 + 8	**16**	1	4 + 0	4	1	2	2	**22**
IV	4	8 + 8	**16**	1	4 + 0	4	1	2	2	**22**
Total Credits	**64**			**16**			**8**			**88**

(T-Theory; P-Practical)

Structure of Curriculum

		First Year				Second Year				Total Credit Value
		Semester I		Semester II		Semester III		Semester IV		
		Credit	Course	Credit	Course	Credit	Course	Credit	Course	
(A)	**Prerequisite and Core Courses**									
	Theory	4	2	4	3	4	2	4	2	36
	Practical	4	2	4	1	4	2	4	2	28
(B)	**Skill Based / Subject Elective Courses**									
1	Theory /Practical	4	1	4	1	4	1	4	1	16
(C)	**Audit Course (No weightage in CGPA calculations)**									
1	Practicing Cleanliness	2	1							2
2	Personality and Cultural Development Related Course			2	1					2
3	Technology Related + Value Added Course					2	1			
4	Professional and Social + Value Added Course							2	1	2
	Total Credit Value	**14**	**6**	**14**	**6**	**14**	**6**	**14**	**6**	**88**

List of Audit Courses (Select any ONE course of Choice from Semester II; Semester III and Semester IV)							
Semester I (Compulsory)		**Semester II** (Choose One)		**Semester III** (Choose One)		**Semester IV** (Choose One)	
		Personality and Cultural Development		**Technology + Value Added Course**		**Professional and Social + Value Added Course**	
Course Code	**Course Title**	**Course Code**	**Course Title**	**Course Code**	**Course Title**	**Course Code**	**Course Title**
AC-101	Practicing Cleanliness	AC-201A	Soft Skills	AC-301A	Computer Skills	AC-401A	Human Rights
		AC-201B	Sport Activities	AC-301B	Cyber Security	AC-401B	Current Affairs
		AC-201C	Yoga	AC-301C	Rainwater Harvesting	AC-401C	Medical Geology
		AC-201D	Indian Music	AC-301D	Geo-tourism	AC-401D	Watershed Management

Semester-wise Course Structure of M.Sc. Applied Geology

Semester I

Course Code	Course Type	Title of the Course	Contact Hours/Week			Distribution of Marks for Examination						Credits
						Internal		External		Total		
			Th	Pr	Total	Th	Pr	Th	Pr	Th	Pr	
GS-101	Skill Based	Mineralogy, Crystallography and Gemology	04	--	04	40	--	60	--	100	--	04
GS-102	Core	Principals of Stratigraphy and Paleontology	04	--	04	40	--	60	--	100	--	04
GS-103	Core	Sedimentology and Geostatistics	04	--	04	40	--	60	--	100	--	04
GS-104	Practical	Practicals related to Mineralogy, Crystallography, Gemology and Paleontology	--	08	08	--	40	--	60	--	100	04
GS-105	Practical	Practicals related to Sedimentology	--	08	08	--	40	--	60	--	100	04
AC-101	Audit Course	Practicing Cleanliness		02	02		100	--	--	--	100	02

Semester-II

Course Code	Course Type	Title of the Course	Contact Hours/Week			Distribution of Marks for Examination						Credits
						Internal		External		Total		
			Th	Pr	Total	Th	Pr	Th	Pr	Th	Pr	
GS-201	Core	Igneous and Metamorphic Petrology	04	--	04	40	--	60	--	100	--	04
GS-202	Core	Physics and Chemistry of the Earth	04	--	04	40	--	60	--	100	--	04
GS-203	Skill Based	Geomorphology, Structural Geology and Tectonics	04	--	04	40	--	60	--	100	--	04
GS-204	Practical	Practicals related to Igneous and Metamorphic Petrology	--	08	08	--	40	--	60	--	100	04
GS-205	Practical	Practicals related to Geomorphology, Structural Geology and Tectonics	--	08	08	--	40	--	60	--	100	04
AC- 201 A/ AC- 201 B/ AC- 201 C/ AC- 201 D	**Audit Course**	**Choose one out of four (AC- 201 A/ AC- 201 B/ AC- 201 C/ AC- 201 D)** (Personality and Cultural Development Related)		**02**	**02**		**100**	--	--	--	**100**	**02**

AC-201 A: Soft Skills **AC-201 B: Sports Activities** **AC-201 C: Yoga** **AC-201 D: Music**

Semester III

Course Code	Course Type	Title of the Course	Contact Hours/Week			Distribution of Marks for Examination						Credits
						Internal		External		Total		
			Th	Pr	Total	Th	Pr	Th	Pr	Th	Pr	
GS-301	Core	Indian Stratigraphy	04	--	04	40	--	60	--	100	--	04
GS-302(A)	Elective	Indian Mineral Deposits, Exploration and Mining	04	--	04	40	--	60	--	100	--	04
GS-302(B)	**Elective**	**Nuclear Geology**	**04**	**--**	**04**	**40**	**--**	**60**	**--**	**100**	**--**	**04**
GS-303	Core	Remote sensing and GIS	04		04	40		40		100		04
GS-304	Practical	Practicals related to Remote sensing and GIS	--	08	08	--	40	--	60	--	100	04
GS-305	Practical	Practicals related to Indian stratigraphy, Indian Mineral Deposits, Exploration and Mining	--	08	08	--	40	--	60	--	100	04
AC- 301 A/ AC-301 B/ AC- 301 C/ AC-301 D	**Audit Course**	**Choose one out of four (AC- 301 A/ AC- 301 B/ AC- 301 C/ AC- 301 D)**		**02**	**02**		**100**	**--**	**--**	**--**	**100**	**02**

List of elective courses to be offered in Semester-III:

GS-302 (A): Indian Mineral Deposits, Exploration and Mining
GS-302 (B): Nuclear Geology

List of Audit courses to be offered in Semester-III:

AC-301 A: Computer Skills (T)
AC-301 B: Cyber Security
AC-3031 C: Rainwater Harvesting
AC-301 D: Geo-tourism

Semester-IV

Course Code	Course Type	Title of the Course	Contact Hours/Week			Distribution of Marks for Examination						Credits
						Internal		External		Total		
			Th	Pr	Total	Th	Pr	Th	Pr	Th	Pr	
GS-401	Core	Hydrogeology	04	--	04	40	--	60	--	100	--	04
GS-402(A)	Elective	Petroleum Geosciences	04	--	04	40	--	60	--	100	--	04
GS-402(B)	**Elective**	**Advanced Surveying in Geosciences**	**04**	**--**	**04**	**40**	**--**	**60**	**--**	**100**	**--**	**04**
GS- 403	Core	Engineering and Environmental Geosciences	04	--	04	40	--	60	--	100	--	04
GS-404	Practical	Practicals related to Petroleum geosciences and Hydrogeology	--	08	08	--	40	--	60	--	100	04
GS-405	Practical	Dissertation/ Internship	--	08	08	--	40	--	60	--	100	04

AC-401 A/ AC-401 B/ AC-401 C/ AC-401 D	**Audit Course**	**Choose one out of four (AC-401 A/ AC-401 B/ AC-401 C/ AC-401 D)**	**--**	**02**	**02**		**100**	**--**	**--**	**--**	**100**	**02**

List of elective courses to be offered in Semester IV:

GS-402 (A): Petroleum Geosciences
GS-402 (B): Advanced Surveying in Geosciences

List of Audit courses to be offered in Semester-IV:

AC-401 A: Human Rights **AC-401 B:** Current Affairs
AC-401 C: Medical Geology **AC-401 D:** Watershed Management

Program at a Glance

- Name of the program (Degree) : M. Sc. (Applied Geology)
- Faculty : Science and Technology
- Duration of the Program : Two years (four semesters)
- Medium of Instruction and Examination : English
- Exam Pattern : 60 : 40 (60 marks University exam
  - and 40 marks continuous internal
  - departmental exam/assessment)
- Passing standards : 40% in each exam separately
  - (separate head of passing)
- Evaluation mode : CGPA
- Total Credits of the program : 88 (64 core credits including 4 credits
  - of project/dissertation, 08 skill
  - enhancement credits, 08 subject
  - elective credits and 08 audit credits)

Eligibility

Bachelor's degree in Geology from any recognized University with at least 50 % marks.

Duration

The duration of M.Sc. (Applied Geology) degree program shall consist of two academic years divided in to four semesters. Each Semester consist of 90 working days. Each theory course will be completed in 60 hours and practical course in 96 hours.

Medium of instruction

The medium of instruction and examination for each course shall be English.

Credit to contact hour

One credit is equivalent to 15 periods of 60 minutes each for theory course lecture.

Attendance

The student enrolled must have 75% attendance in each course in order to appear for term end examinations, otherwise the candidate may not be allowed to appear for term end examination as per the Rules.

Examination

Each theory and practical course will be of 100 marks comprising of 40 marks for internal (20 marks of 2 internal examinations) and 60 marks external examination. Separate head of passing in Internal and External examination is mandatory. In case of failure in internal examination of particular course, student will have to appear for the same in next semester as per the schedule of the examination. In case a student fails in particular course in a semester and the same course(s) are revised/removed from curriculum in due course, the student will have to appear as per new curriculum and or pattern in subsequent semester at his own responsibility.

Program Objectives for M.Sc. Program:

1. To impart the profound theoretical and practical knowledge of the specific science discipline along with the fundamental core concepts
2. To train the students to employ modern techniques, tools, methodologies, equipment, hardware/software etc. to perform objective oriented scientific and planned experiments.
3. To groom the students for all-round development and mould them in a trained workforce to provide teaching-learning, research, business, professional supports in the various science disciplines.
4. To make the student to develop the ability to think analytically, independently and draw logical conclusions to solve real-life problems.
5. To utilize the skills and knowledge gained through the subject to deal with real life situations and problems related to society, environment, research and development etc.

Program Outcomes (PO) for M.Sc. Program:

Upon successful completion of the M.Sc. program, student will be able to:

PO No.	Program Outcomes	Cognitive level
PO1	Understand the basic concepts, fundamental principles, and the scientific theories related to various scientific phenomena and their relevancies in the day-to-day life.	**2**
PO2	Administer the skills in handling scientific instruments, planning and performing in laboratory experiments	**3**
PO3	Analyse the given scientific experimental data critically and systematically and the ability to draw the objective conclusions.	**4**
PO4	Develop various skills such as communication, managerial, leadership, entrepreneurship, teamwork, social, research etc., which will help in expressing ideas and views clearly and effectively	**3**
PO5	Model and formulate the real problems and find solution based-on knowledge acquired	**6**

PO6	To evaluate how developments in any science subject helps in the development of other science subjects and vice-versa and how interdisciplinary approach helps in providing better solutions and new ideas for the sustainable developments.	**5**

Program Specific Objectives for M.Sc. Applied Geology program:

1. To produce skilled experts with applied aspects of Geology employable for positions in the field of education, industry and government and non-government organizations.
2. To impart knowledge on advances and challenges in Geological sciences.
3. To impart technical/analytical methodologies for evaluation of resources like groundwater, minerals, and rocks.
4. To provide knowledge on methodologies for groundwater exploration and mineral exploration for sustainable development
5. To prepare our graduates to become effective scientific communicators/collaborators in multidisciplinary teams providing technical leadership to engage with the challenging geological problems of local, national, and global nature.

Program Specific Outcomes (PSOs) for M.Sc. Applied Geology program:

Students who graduate with a Master of Science in Applied Geology will:

PSO No.	Program Specific Outcomes	Cognitive level
PSO1	Demonstrate an understanding of structure, chemistry and crystallography of the minerals and to understand the role of minerals in economy and its advantages and disadvantages in industry, health and environment.	**2**
PSO2	Gain proficiency in laboratory techniques in identification of rocks and minerals, geomorphic landforms and they will be able to apply the scientific methods of resource exploration and geomaterial testing.	**3**
PSO3	Acquire significant knowledge on various aspects related to petrology, mineralogy, geomorphology, mineral exploration, mining, petroleum exploration and technical skills related to groundwater exploration, engineering geological investigations and environmental geological aspects.	**4**
PSO4	Learn to work as a team as well as independently to retrieve information, carry out Research investigations and result interpretations.	**6**
PSO5	Develop the ability to understand and practice the ethics surrounding scientific Research.	**5**
PSO6	Realize the impact of science in society and plan to pursue research.	**5**

M. Sc. (Applied Geology)

SYLLABUS

Distribution of Course papers for M. Sc. Part I Applied Geology

Subject Code	Title of the Paper		Duration (Hrs./Wk)	Max. Mark	Exam. Time (Hrs.)
M.Sc. Part I (Applied Geology)					
Semester I : Theory Courses					
GS-101	Mineralogy, Crystallography and Gemology	Skill Based	04	100	03
GS-102	Principals of Stratigraphy and Paleontology	Core course	04	100	03
GS-103	Sedimentology and Geostatistics	Core course	04	100	03
Semester I : Practical Courses					
GS-104	Practicals related to Mineralogy, Crystallography, Gemology and Paleontology	Core course	**04+04**	**100**	**06**
GS-105	Practicals related to Sedimentology	Core course	**04+04**	**100**	**06**
AC-101	Practicing Cleanliness	Audit Course	**02**	**100**	
Semester II : Theory Courses					
GS-201	Igneous and Metamorphic Petrology	Core course	**04**	**100**	**03**
GS-202	Physics and Chemistry of the Earth	Core course	**04**	**100**	**03**
GS-203	Geomorphology, Structural Geology and Tectonics	Skill Based	04	100	03
Semester II : Practical Courses					
GS-204	Practicals related to Igneous and Metamorphic Petrology	Core course	**04+04**	**100**	**06**
GS-205	Practicals related to Geomorphology, Structural Geology and Tectonics	Core course	04+04	100	06
AC-201A/B/C/D	Choose one out of Four (AC-201A/ AC-201B/ AC-201C/ AC-201D) from Personality and Cultural Development (Audit Course)	Audit Course	**02**	**100**	

M. Sc. PART I (APPLIED GEOLOGY)
(SEMESTER – I)

SKILL BASED COURSE		
GS-101: MINERALOGY, CRYSTALLOGRAPHY AND GEMOLOGY		
	Course Objectives: 1. To learn the phenomenon, concept and principles of mineral formation. 2. To learn the different types of silicate and Non-silicate minerals. 3. To learn crystals, gems and their applicability. 4. To learn sophisticated instrumentation techniques. 5. Megascopic and microscopic study of minerals for its identification and classification.	
Unit 1	**Mineral Optics and Introduction to Instruments** 1. Isotropic and anisotropic substances; Reflection, refraction and refractive index; Relief, birefringence and Becke line effect; Optically uniaxial and biaxial minerals; Determination of optic sign of uniaxial and biaxial minerals; interference figures; Pleochroism and determination of pleochroic scheme in minerals 2. X-ray crystallography and Bragg's equation; Application of X-ray diffraction spectrometry in mineral characterization 3. Application of following techniques in mineralogy: Differential Thermal Analysis (DTA), Thermogravimetric Analysis (TGA), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM) and Electron Probe Micro Analyser (EPMA) 4. Application of thermal, magnetic and radioactive properties of minerals	**10 L**
Unit 2	**Introduction to Mineralogy and Study of Non-Silicates** 1. Principle of crystal structure; Bonding in minerals; Coordination and co-ordination numbers; Silicate structures and structural formula; Isomorphism and solid solution; Types of ionic substitution; Polymorphism and types of polymorphic transformations and Pseudomorphism Conversions of oxide and element weight percentages; Calculation of mineral formulae 2. A detailed study of Non-silicates mineral groups with reference to their general formulae, classification, atomic structure, chemistry, experimental work and paragenesis of Non-silicates: Carbonates- Calcite Group, Aragonite Group, Dolomite Group; Phosphates- Apatite, Monazite; Sulphates- Gypsum, Anhydrite, Barite, Alunite Group; Halides- Halite, Sylvite, Fluorite; Nitrates- Trona, Soda niter; Oxides and Hydroxides- Spinel Group, Hematite Group, Rutile Group, Bauxite Group, Periclase	**15 L**
Unit 3	**Mineralogy of Silicates** 1. A detailed study of Silicate mineral groups with reference to their general formulae, classification, atomic structure, chemistry, experimental work and paragenesis of Silicates: Nesosilicates- Olivine Group, Garnet Group and Aluminosilicate Group; Sorosilicates- Epidote Group, Scapolite Group; Cyclosilicates- Beryl, Tourmaline; Inosilicates- Pyroxene Group, Amphibole Group; Phyllosilicate- Mica Group, Chlorite Group, Serpentine Group, Pyrophyllite, Talc; Tectosilicates- Quartz, Feldspars, Feldspathoides and zeolite Group	**15 L**

Unit 4	**Crystallography** 1. Crystals, crystalline solids and their formation; Ordered patterns, nets and lattices; Symmetry in crystals; Axial ratio, indices, lettering and order of the crystallographic axes; Crystallographic notation (Weiss and Miller indices and convention in notation) 2. Classification of crystals, introduction to 32 classes of symmetry; The crystal systems and symmetry types; Stereographic representation of crystal symmetry and their uses; Imperfection of crystals and crystal defects; Twinning- causes, effects and genetic types	**10 L**
Unit 5	**Gemology** 1. Physical properties, Optical properties and Chemical properties of inorganic gems like Diamond, corundum, beryl, chrysoberyl, garnet, spinel, topaz, tourmaline, zircon, peridot, jadeite, nephrite, opal, quartz, chalcedony, orthoclase, moonstone, labradorite, lapis lazuli, apatite, cordierite, zoisite, malachite, bowenite, denburite, diopside, enstatite, serpentine, steatite, natural glasses (obsidian and moldavite) 2. Study of Organic gems like pearl, corals etc., their formation, structure and identification 3. Introduction to instruments used in the study of gems	**10 L**

Suggested readings:

1. Battey, M.H. (1981) Mineralogy for students 2nd Edn. Longmans.
2. Berry, L.G. and Mason, B. and Dietrich, R.V. (1983) Mineralogy, 2nd Edn, Freeman.
3. Bunn, C.W. (1961) Chemical Crystallography, Clarendon.
4. Donald Bloss (1971) Crystallography and Crystal chemistry, Holt, Rinehart and Winston.
5. Deer, W.A., Howie, R.A., and Zussman, J. (1992) An Introduction to the rock forming minerals, Longman.
6. Hutchinson, C.S. (1974) Laboratory Handbook of Petrographic Techniques, John Wiley.
7. Klein, C. and Hurlbut, Jr., C.S. (1993) Manual of Mineralogy, John Wiley.
8. Kerr, P.F. (1977) Optical Mineralogy 4th Edn., McGraw-Hill.
9. Phillips, Wm, R. and Griffen, D.T. (1986) Optical Mineralogy, CBS Edition.
10. Putnis, Andrew (1992) Introduction to Mineral Sciences, Cambridge University Press.
11. Santosh, M. (1988) Fluid Inclusions, Geological Society of India, Banglore.
12. Spear, F.S. (1993) Mineralogical Phase Equilibria and Pressure -Temperature-Time Paths, Mineralogical Society of America Publication.
13. Winchell, A.N. (1962) Elements of Optical Mineralogy, John Wiley.
14. Slemmons, D.B. (1962).Determination of Volcanic and Plutonic Plagioclases using a three- or Four- Axis Universal Stage, Geological Society of America.
15. Szymanski, A. (1988). Technical Mineralogy and Petrography, Elsevier.

Course Outcomes (COts):

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C 101.1	Students will be able to identify minerals	**2**
C 101.2	Students will be able to identify gems	**2**
C 101.3	Students will be able to operate the sophisticated instruments	**3**

CORE COURSE		
GS-102: PRINCIPALS OF STRATIGRAPHY AND PALAEONTOLOGY		
	Course Objectives: 1. To learn the phenomenon, concepts and applicability of the stratigraphy. 2. To learn the different types of startigraphic correlations. 3. To learn distribution of Invertebrate and vertebrate organic remnant. 4. To learn the use of paleontological data in Stratigraphy, Paleoecology, Paleogeography and oil exploration. 5. To learn trends and advancements in the subject Paleontology.	
Unit 1	**History and development** 1. History and development of Stratigraphy 2. Stratigraphic procedures (Surface and Subsurface) 3. Concept of Litho-facies and Bio-facies	**10 L**
Unit 2	**Stratigraphic Correlation** 1. Stratigraphic Correlation (Litho-, Bio- and Chrono-stratigraphic Correlation 2. Study of standard stratigraphic code (Lithostratigraphic, Biostratigraphic and Chronostratigraphic) 3. Concepts of Magnetostratigraphy, Chemostratigraphy, Event stratigraphy, and Sequence stratigraphy 4. Techniques in Palaeontology - megafossils - microfossils - nannofossils - ichnofossils - collection, reformation and illustration - binomial nomenclature	**15 L**
Unit 3	**Invertebrate Paleontology** 1. Invertebrate Paleontology - A brief study of morphology, classification, evolutionary trends and distribution of Molluscs i.e. Bivalves, Gastropods and Cephalopods 2. Study of morphology, classification, evolutionary trends and distribution of Trilobites, Graptolites, Echinoids, Corals and Brachiopods	**15 L**
Unit 4	**Vertebrate Paleontology** 1. Vertebrate Paleontology - Study of vertebrate life through Geologic time scale 2. Study of reptiles, birds, fishes and mammals	**10 L**
Unit 5	**Paleontological perspective** 1. Introduction to Micropaleontology, Types of Microfossils, paleo palynology 2. Foraminifera and Ostracods 3. Plants of Gondwana Period 4. Paleontological perspective: Use of paleontological data in a) Stratigraphy b) Paleo-ecology c) Paleogeography	**10 L**

Suggested readings:

1. Boardman, R.S., Cheethan, A.M. and Rowell, A.J. (1988) Fossil Invertebrates, Blackwell.
2. Clarksons, E.N.K. (1998) Invertebrate Paleontology and Evolution, Allen and Unwin, London.
3. Dobzhansky, Ayala, Stebbins and Valentine (1977) Evolution, Freeman.
4. Horowitz, A.S. and Potter, E.D. (1971) Introductory Petrography of Fossils, Springer Verlag.
5. Mayr, E. (1971) Population, Species and Evolution, Harvard.
6. Prothero, D.R. (2004) Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill.
7. Raup, D.M. and Stanley, S.M. (1985) Principles of Paleontology, CBS Publishers, New Delhi.
8. Smith, A.B. (1994) Systematics and Fossil Record – Documenting Evolutionary Patterns, Blackwell.
9. Strean, C.W. and Carroll, R.L. (1989) Paleontology – the record of life, John Wiley.

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C102.1	Students will be able to identify different types of fossils.	**2**
C102.2	Students will be able to correlate various stratigraphic units.	**2**
C102.3	Students will be able to use of paleontological data in any geological application.	**3**

CORE COURSE		
GS - 103: SEDIMENTOLOGY AND GEOSTATISTICS		
	Course Objectives: 1. To learn field procedures in sedimentary petrology 2. To learn and identify various sedimentary rock textures and structures 3. To learn petrography of sedimentary rocks of clastic, chemical and biochemical origin. 4. To learn the relation of sedimentation and tectonics. 5. To learn Palaeocurrent and depositional basins.	
Unit 1	**Field procedures** 1 Field procedures in Sedimentary Petrology 2 Geologic cycle 3 Sedimentary textures (Granulometric analysis, shape and roundness studies, surface textures) 4 Heavy mineral and Insoluble residue analysis	**10 L**
Unit 2	**Petrography** 1 Petrography of rocks of clastic, chemical and biochemical origin (Conglomerates, Sandstone, Mudstone, Limestone and Dolomite) 2 Evaporite, Phosphorite, Chert, Iron and Manganese rich sediments 3 Volcanogenic sedimentary rocks	**15 L**
Unit 3	**Sedimentary structures, Textures and fluid flow** 1. Sedimentary structures (Physical structures, Biogenic sedimentary structures, Diagenetic structures). 2. Sedimentary Textures. 3. Clastic transport and fluid flow (fluid flow in theory and in nature, Reynold's Numbers, Froude Number, Sediment lift, transport, deposition, sedimentary gravity flow)	**10 L**
Unit 4	**Sedimentation and Tectonics** 1. Concept of Sedimentary facies association models (Marine, Nonmarine, and Mixed Depositional Environment) 2. Sedimentation and Tectonics 3. Paleocurrents and Basin Analysis.	**10 L**
Unit 5	**Basic concepts of Geostatistics** 1. Basic concepts of Geostatistics; Arithmetic mean, Mode, Median, Range, Variance, Frequency, Skewness, Kurtosis, Standard Deviation, Probability; Distributions: Binomial, Poisson, Normal, Gamma, Exponential, Hypergeometric, Multinomial and Chi-square 2. Introduction to computer software used in earth sciences 3. Application of geostatistical techniques to earth sciences; Use of computers and software as tools in the areas of geological problem-solving, report-writing, and presentations	**15 L**

Suggested readings:

1. Blatt, H., Middleton, G.V. and Murray, R.C. (1980) Origin of Sedimentary Rocks, Prentice-Hall Inc.
2. Collins, J.D. and Thompson, D.B. (1982) Sedimentary Structures, George Allen and Unwin, London.
3. Lindholm, R.C. (1987) A Practical Approach to Sedimentology, Allen and Unwin, London.
4. Miall, A.D. (2000) Principles of Basin Analysis, Springer-Verlag.
5. Pettijohn, F.J. (1975) Sedimentary Rocks (3rd Ed.), Harper and Row Publ., New Delhi.
6. Reading, H.G. (1997) Sedimentary Environments and facies, Blackwell Scientific Publication.
7. Reineck, H.E. and Singh, I.B. (1973) Depositional Sedimentary Environments, Springer-Verlag.
8. Selley, R.C. (2000) Applied Sedimentology, Academic Press.
9. Tucker, M.E. (1981) Sedimentary Petrology: An Introduction, Wiley and Sons, New York.
10. Tucker, M.E. (1990) Carbonate Sedimentolgy, Blackwell Scientific Publication.
11. Hota, R.N. (2011) Practical Approach to Petrology, CBS Publisher and Distributors Pvt Ltd., New Delhi
12. Isaaks, E.A. and Srivastava, R.M. (1990) An Introduction to Geostatistics, Oxford University Press
13. Armstrong, M. (1998) Basic linear geostatistics, Springer Verlag, Berlin
14. Duruble, O. (1998) Geostatistics in Petroleum Geology, AAPG Cont. Education Course Note Series 38.
15. Goovaerts, P. (1997) Geostatistics for Natural Resources Modelling, Oxford University Press, Oxford.

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C103.1	Students will be able to identify different types of sedimentary rocks.	**2**
C103.2	Students will be able to illustrate various morphological characteristics of sedimentary terrain.	**3**
C103.3	Students will be able to plan their career in the field of Sedimentology.	**4**

CORE COURSE	
GS-104: PRACTICALS RELATED TO MINERALOGY, CRYSTALLOGRAPHY AND GEMOLOGY	
	Course Objectives: 1. To learn optical phenomenon, characteristics of minerals and their identification. 2. To construct lithologs and learn to correlate different litho-sections. 3. To learn the paleontological techniques for classification of mega and micro fossils. 4. To learn Palaeocurrent and depositional basins. 5. To learn microfossil slide preparation.
1	Study of interference figures - determination of optical sign of minerals, determination of 2V and 2E, determination of composition of plagioclase feldspars- determination of birefriengence of minerals - Scheme of pleochroism
2	Construction of Stereograms and Gnomonograms - measurement of interfacial angle with contact goniometer - study of X-ray diffractograms
3	Study of rock forming minerals in thin sections
4	Study of rock forming minerals in hand specimens
5	Construction of rank charts for lithostratigraphy, biostratigraphy and chronostratigraphy
6	Construction of graphical logs from text descriptions
7	Exercises in correlation from given data or logs
8	Study of palaeontological technique related to megafossils.
9	Study of morphology of Bivalves, Gastropods Echinoids, Brachiopods
10	Separation, Processing, wet sieve analysis, preparation of slides of microfossils
11	Morphology and morphological descriptions of planktonic and benthonic foraminifera, Ostracodes

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C104.1	Students will be able to identify and classify rock forming minerals.	**2**
C104.2	Students will be able to explain crystal by constructing stereograms and Gnomograms.	**3**
C104.3	Students will be able to plan their career in the field of Gemology, mineralogy and in oil and gas sector.	**4**

CORE COURSE	
GS-105: PRACTICALS RELATED TO SEDIMENTOLOGY	
	Course Objectives: 1. To learn techniques of size and shape analysis of sediments. 2. To learn procedures and identification of heavy minerals present in sediments. 3. To learn calculations of paleocurrent and basin analysis. 4. To identify and classify sedimentary rocks and their structure and texture.
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	Insoluble residue analysis (Procedure and identification)
5	Megascopic and studies of conglomerate and breccia
6	Study of Volcanogenic sedimentary rocks
7	Megascopic and microscopic study of sandstone
8	Megascopic and microscopic study of limestone
9	Sedimentary structure (Identification and classification)
10	Paleocurrent and basin analysis calculation

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C105.1	Students will be able to identify sedimentary rocks.	**2**
C105.2	Students will be able to classify sedimentary rocks.	**4**
C105.3	Students will be able to analyze and calculate sedimentary basin characteristics.	**4**

M.Sc. Part I Semester I (Applied Geology): Audit Courses

AC-101: Practicing Cleanliness
(Compulsory; Campus-level Audit Course; Practical; 2 Credits)

Course Objectives (CObs):

- To make students aware of Clean India Mission and inculcate cleanliness practices among them.

- Awareness program on
  - Swachh Bharat Abhiyan (Clean India Mission)
  - Clean Campus Mission
  - Role of youth in Clean India Mission
- Cleaning activities inside and surroundings of Department buildings.
- Tree plantation and further care of planted trees
- Waste (Liquid/Solid/e-waste) Management, Japanese 5-S practices
- Planning and execution of collection of Garbage from different sections of University campus
- Role of youth in power saving, pollution control, control of global warming, preservation of ground water and many more issues of national importance.
- Cleanest School/Department and Cleanest Hostel contests
- Painting and Essay writing competitions

Course Outcomes (COts):

On completion of this course, the student will be able to:

COt No.	Course Outcomes	Cognitive level
AC101.1	Identify need at of cleanliness at home/office and other public places.	**2**
AC101.2	Plan and observe cleanliness programs at home and other places.	**4**
AC101.3	Practice Japanese 5-S practices in regular life.	**3**

M. Sc. PART I (APPLIED GEOLOGY)
(SEMESTER – II)

CORE COURSE

GS-201: IGNEOUS AND METAMORPHIC PETROLOGY

Course Objectives:

1. To learn the phenomenon, concept and factors playing important role in Igneous and metamorphic petrology.
2. To learn different types of equipments used in Petrological studies.
3. To learn various processes and factors controlling evaluation of magma.
4. To learn classification of igneous and metamorphic rocks.
5. To learn textures and structures of igneous rocks and metamorphic rocks.

Unit 1	**Igneous Petrology** 1. Magma- its nature and composition. Factors controlling evolution of magma 2. Classification of Igneous rocks - historic perspective and the IUGS systematic 3. Introduction to mantle petrology mantle metasomatism and mantle heterogeneities 4. Magmatism in relation to plate tectonics 5. Chemical characteristics of igneous rocks in the following tectonic setting: Mid Oceanic Ridge, Island Arcs, Oceanic plateaus, Continental Margins, Continental Rifts and Continental intraplate; Plume magmatism and hot spots; large igneous provinces, mafic dyke swarms and layered complexes 6. Equipments used in petrological study: Scanning electron microscope (SEM), electron Probe Microanalysis (EPMA), Atomic Absorption Spectrophotometry, Inductively Coupled Plasma Mass Spectrometry (ICPMS) and infrared spectrometers	**10 L**
Unit 2	**Igneous Petrology** 1. Mantle melting: Partial melting (batch and fractional melting); Crystal fractionation (equilibrium and fractional (Rayleigh) crystallization); Contamination (AFC process) and dynamic melting 2. Crystallisation of magma, fractional crystallization and differentiation, liquid immiscibility and assimilation. Influence of volatiles and role of oxygen fugacity in magmatic crystallizations 3. Phase equilibrium studies - binary systems, ternary systems and their relations to magma genesis and crystallization in the light of modern experimental works	**15 L**
Unit 3	**Igneous Petrology** 1. Textures and structures of igneous rocks; Petrography and Interpretation of igneous textures in terms of rate of nucleation and crystal growth 2. Major, Trace and Rare Earth Element systematics in igneous rocks 3. Silica/alumina saturation, variation diagrams (Harker, AFM and TAS diagrams) their applications and limitations; Mg Number, Alteration Index,	**15 L**

	Saturation Index and other geochemical parameters 4. Fractional crystallization, liquid lines of descent and lever rule 5. Indian Igneous Rocks and their genesis	
Unit 4	**Metamorphic Petrology** 1. Types of metamorphism and their controlling factors 2. Grades of Metamorphism 3. Common minerals of metamorphic rocks 4. Metamorphic Texture and Structures 5. Prograde and retrograde metamorphism, Metasomatism 6. Metamorphic facies	**10 L**
Unit 5	**Metamorphic Petrology** 1. Phase diagrams and graphic representation of mineral assemblages 2. Metamorphic reactions, elemental exchange and P-T conditions of isograds 3. Plate tectonics and metamorphic processes 4. Paired metamorphic belts, Archaean and Proterozoic terrains Pressure-temperature time paths in regional metamorphic rocks, Polymetamorphism	**10 L**

Suggested readings:

1. Best, M. G. (2003) Igneous and Metamorphic Petrology, 2nd Edn., Blackwell.
2. Bose, M.K. (1997) Igneous Petrology, World Press, Kolkata.
3. Cox, K. G., Bell, J. D. and Pankhurst, R. J. (1979) The Interpretation of Igneous Rocks, Unwin Hyman.
4. Faure, G. (2001) Origin of Igneous Rocks, Springer.
5. Hall, A. (1996) Igneous Petrology, 2nd Edn., Longman.
6. LeMaitre R.W. (2002) Igneous Rocks: A Classification and Glossary of Terms, Cambridge Uni. Press.
7. McBirney, A.R. (2006) Igneous Petrology, 3rd Edn., Jones and Bartlett.
8. Middlemost, E.A.K. (1985) Magmas and Magmatic Rocks, Longman.
9. Parfitt, E. and Wilson, L. (2008) Fundamentals of Physical Volcanology, Wiley-Blackwell.
10. Phillpotts, A.R. (1994) Principles of Igneous and Metamorphic Petrology, Prentice Hall of India.
11. Sood, M.K. (1982) Modern Igneous Petrology, Wiley-Interscience Publ., New York.
12. Srivastava, R.K. and Chandra, R. (1995) Magmatism in Relation to Diverse Tectonic Settings, A.A. Balkema, Rotterdam.
13. Wilson, M. (1993) Igneous Petrogenesis, Chapman and Hall, London.
14. Winter, J.D. (2001) Introduction to Igneous and Metamorphic Petrology, Prentice-Hall.
15. Bell, Keith (Ed.) (1989) Carbonatites: Genesis and Evolution, Unwin Hyman, London.
16. Bell, K., Kjarsgaard, B.A. and Simonetti, A. (1998) Carbonatites – Into the twenty-first Century, Journal of Petrology, Spl. Vol.39 (11 and 12).
17. Carmichael, J., Turner and Verhoogen (1974) Igneous Petrology, McGraw Hill.
18. Fitton, J.G. Upton, B.J.G. (Eds) (1987) Alkaline Igneous Rocks, Geological Society, London.
19. LeBas, M.J. (1977) Carbonatite-nephelinite Volcanis, Wiley.
20. Rock, N.M.S., (1991) Lamprophyres, Blackie, Glasgow.
21. Perchuk, L.L. and Kushiro, I. (Eds.) (1991) Physical Chemistry of Magmas, Springer Verlag.
22. Gupta, Alok (1998) Igneous Rocks, Allied Publishers Limited.
23. Allegre, C.J. and Hart, S.R. (1979) Trace elements in Igneous Petrology, Elsevier.
24. Hughes, C.J. (1982) Igneous Petrology, Elsevier.
25. Hota, R.N. (2011) Practical Approach to Petrology, CBS Publisher and Distributors Pvt Ltd., New Delhi.
26. Harker, Alfred (1964) Metamorphism, Methuen, London.

27. Turner, F.J. (1980) Metamorphic Petrology, McGraw Hill, New York.
28. Yardlley, B.W.D. (1989) An introduction to Metamorphic Petrology, Longman Scientific and Technical, New York.
29. Philopotts, A.R. (1994) Principles of Igneous and Metamorphic Petrology, Prentice Hall.
30. Bhaskar Rao, B. (1986) Metamorphic Petrology, IBH and Oxford.

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C201.1	Students will be able to identify different types of igneous rocks.	**2**
C201.2	Students will be able to identify different types of metamorphic rocks.	**2**
C201.3	Students will be able to operate sophisticated instruments.	**3**

CORE COURSE		
GS-202: PHYSICS AND CHEMISTRY OF THE EARTH		
	Course Objectives: 1. To learn concepts of universe and planetary system. 2. To learn concepts of paleomagnetism and earth magnetic field. 3. To learn geochemical classification and distribution of elements. 4. To learn techniques of geochronology and age of earth determination methods. 5. To learn geochemical methods useful in solving geological problems.	
Unit 1	**Universe and Planetary System** 1. Origin and components of solar system 2. Meteorites and their classification 3. Earth in relation to the solar system and universe 4. Cosmic Abundances of elements 5. Composition of the planets and meteorites	**10 L**
Unit 2	**Physics of the Earth** 1. Seismic waves and their velocities 2. Internal structure of the earth 3. Density distribution, shape and mass of the earth. density Vs depth profile 4. Gravity and gravitational mechanics, gravity anomalies and their interpretation 5. The earth as Magnet, Earth's magnetic field, changes in magnetic field, origin of geomagnetic field, paleomagnetism	**15 L**
Unit 3	**Introduction to Geochemistry** 1. Introduction to Geochemistry – its scope, Geochemical Classification of the elements 2. Geochemical Cycle, path finder Elements, threshold values and Mode of Occurrence 3. Geochemical classification and distribution of elements in the earth 4. Structure and atomic properties of elements 5. The Periodic table 6. Laws of Thermodynamics and phase diagrams 7. Geochemistry of hydrosphere, biosphere and atmosphere 8. Elementary crystal chemistry and thermodynamics 9. Structure Composition and evolution of the earth and distribution of elements	**15 L**

Unit 4	**Geochronology and age of the Earth** 1. Law of Radioactivity 2. Principles of isotopic dating, Decay schemes and Derivation of equation of age 3. Introduction to isotope geochemistry 4. Rb/Sr, U-Th-Pb methods of dating the rocks 5. Age of the Earth. 6. Trace elements	**10 L**
Unit 5	**Geochemical Methods** 1. Geochemical methods – Geochemical Anomalies – Dispersion patterns – Geobotanical indicators of minerals – surface and subsurface methods of sampling. 2. Geological Principles of ore search – Introduction to Assaying and valuation of mineral deposits	**10 L**

Suggested readings:

1. Telford, W.M., Geldart, L.P., Sherrif, R.E. and Keys, D.A. (1976) Applied Geophysics, Cambridge Univ. Press.
2. Howel, B.F. (1959) Introduction to Geophysical Prospecting, McGraw Hill.
3. Lowrie, W. (1997) Fundamentals of Geophysics, Cambridge University Press.
4. Mussett, A.E. and Khan, M.A. (2000) Looking into the Earth: An Introduction to Geological Geophysics, Cambridge University Press.
5. Sharma, P.V. (1986) Geophysical Methods in Geology, Elsevier.
6. Allegre, C.J. and Michard, G. (1974) Introduction to Geochemistry, Reidel, Holland.
7. Anderson, G.M. (2005) Thermodynamics of Natural Systems, Cambridge University Press.
8. Winter, J.D. (2001) Introduction to Igneous and Metamorphic Petrology. Prentice-Hall.
9. Bloss, F.D. (1971) Crystallography and Crystal Chemistry, Holt, Rinehart, and Winston, New York.
10. Drever, J.I. (1997) The Geochemistry of Natural Waters, 3rd Edn., Prentice Hall.
11. Evans, R.C. (1964) Introduction to Crystal Chemistry, Cambridge Univ. Press.
12. Faure, G. (1998) Principles and applications of geochemistry, 2nd Edn., Prentice Hall, New Jersy, 593p.
13. Faure, G. (1986) Principles of Isotope Geology, 2nd Edn., John Wiley.
14. Hoefs, J. (1980) Stable Isotope Geochemistry, Springer-Verlag.
15. Klein, C. and Hurlbut, C.S. (1993) Manual of Mineralogy, John Wiley and Sons, New York.
16. Krauskopf, K.B. (1967) Introduction to Geochemistry, McGraw Hill.
17. Mason, B. and Moore, C.B. (1991) Introduction to Geochemistry, Wiley Eastern.
18. Rollinson, H.R. (1993) Using geochemical data: Evaluation, Presentation, Interpretation, Longman U.K.
19. Wood, B.J. and Fraser, D.G. (1977) Elementary Thermodynamics for Geologists, Oxford University Press, London.
20. Rastogy, R.P. and Mishra, R.R. (1993) An Introduction to Chemical Thermodynamics, Vikash Pub. House.
21. Anderson, G.M. and Crerar, D.A. (1993) Thermodynamics in Geochemistry- the equilibrium model, Oxford University Press, New York.
22. Fletcher, P. (1993) Chemical thermodynamics for earth sciences. Longman Scientific and Technical, London.

Glasstone, S. (1947) Thermodynamics for Chemists, East and West Pub.

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C202.1	Students will be able to summarize various physical and chemical concepts of the earth.	2
C202.2	Students will be able to classify various instruments and methods regarding dating of rocks.	2
C202.3	Students will be able to classify various instruments and methods regarding anomalies in earth gravity and earth magnetism.	2

SKILL BASED COURSE		
GS-203: GEOMORPHOLOGY, STRUCTURAL GEOLOGY AND TECTONICS		
	Course Objectives: 1. To learn the concepts, types and tools of geomorphology. 2. To learn variation in terrain characteristics for mapping landforms of the area. 3. To study Drainage Morphometry and slope analysis for solving various geological problems. 4. To learn applicability of geomorphology in the field of geohydrology, mineral prospecting, engineering geology, watershed management, urban planning and environmental studies. 5. To develop the skill for interpretation, analysis and identification of geological structures. 6. To study the dynamism of the earth in perspective of tectonism, seismicity and heterogeneity of geological processes.	
Unit 1	**Introduction to Geomorphology** 1. Introduction to Geomorphology : History, basic concepts type and tools 2. Landforms : Role of lithology, climate and tectonics 3. Denudational processes - weathering, erosion, transportation, weathering products and soils - profiles, types, duricrusts 4. Hillslopes : Their characteristics and development, fluvial processes on hill slopes 5. River and Drainage basin: Drainage patterns, network characteristics, Valleys and their development. Process of river erosion, transportation and deposition.	**10 L**
Unit 2	**Geomorphic Landforms and Applied Geomorphology** 1. Landforms produced by geomorphic agents a) Fluvial b) Coastal c) Aeolian, d) Glacial, e) Karst and Desert landforms 2. Applied Geomorphology: Application of geomorphology in geohydrology, mineral prospecting, engineering geology, watershed management, urban planning and environmental studies 3. Geomorphology of India: Geomorphological features and zones 4. Geomorphic mapping 5. Slope analysis and drainage basin analysis 6. Physiographic zones of Maharashtra 7. Topographical maps	**15 L**

Unit 3	**Introduction to Structural Geology** 1. Principles of geological mapping and map reading 2. projection diagrams 3. Mechanical principles of rock deformation, 4. Behavior of rock material under stress, strain analysis 5. Classification and genesis of folds, faults, lineations, foliations, joints and fractures	**15 L**
Unit 4	**Structural Analysis** 1. Scope of structural analysis, concept of Tectonite fabric and Tectonite Symmetry 2. Structural analysis on microscopic, mesoscopic and macroscopic scales 3. Introduction to petro fabrics 4. Structural behavior of igneous rocks, diapers and salt domes diapers and salt domes	**10 L**
Unit 5	**Tectonics** 1. Structure and physical characters of continental and oceanic crust 2. seismic belts of the earth 3. Continental drift – geological and geophysical evidence, mechanics, objections, present status 4. Sea - floor spreading and Plate Tectonics, Structure and Tectonics of divergent margins, transform faults, convergent margins 5. Geodynamics of the Indian Plate and Tectonic framework of India 6. Heterogeneity of the earth's crust 7. seismicity and Plate movements 8. Neotectonics - Features and evidences-characteristic landforms, Methods of analysis 9. Orogeny and epeirogeny 10. Isostasy 11. Gravity and magnetic anomalies at Mid-ocean ridges, deep sea trenches, continental shield areas and mountain chains, , Island arcs, Oceanic islands and volcanic arcs,	**10 L**

Suggested readings:

1. Ghosh, S.K. (1993) Structural Geology: Fundamental and Modern Developments, Pergamon Press.
2. Hobbs, B.E., Means, W.D. and Williams, P.F. (1976) An outline of Structural Geology, John Wiley and Sons, New York.
3. Ramsay, J.G. (1967) Folding and fracturing of rocks, McGraw Hill.
4. Ramsay, J.G. and Huber, M.I. (1983) Techniques of Modern Structural Geology, Vol. I, Strain Analysis, Academic Press.
5. Ramsay, J.G. and Huber, M.I. (1987) Techniques of Modern Structural Geology, Vol. II, Folds and Fractures, Academic Press.
6. Ramsay, J.G. and Huber, M.I. (2000) Techniques of Modern Structural Geology, Vol. III (Application of continuum mechanics), Academic Press.
7. Turner, F.J. and Weiss, L.E. (1963) Structural analysis of Metamorphic Tectonites, McGraw Hill.
8. Marshak, S. and Mitra, G. (1988) Basic methods of Structural Geology, Prentice-Hall, New Jersey.
9. Condie, K.C. (1989) Plate Tectonics and Crustal Evolution, 3rd Ed., Pergamon, Oxford Press.
10. Kearey Phillips and Vine, F.J. (1996) Global Tectonics, Blackwell Science, Oxford.
11. Windley, B.F. (1977) The Evolving Continents, John Wiley and Sons, New York.
12. Moores, E and Twiss, R.J. (1995) Tectonics. Freeman.
13. Keary, P., Klepeis, K.A. and Vine, F.J. (2012) Global Tectonics. Third Edition (Reprint), Wiley-Blackwell, Wiley India Pvt. Ltd.
14. Storetvedt, K.N. (1997) Our Evolving Planet: Earths History in New Perspective. Bergen (Norway), Alma Mater Fortag.
15. Patwardhan, A.M. (1999) The Dynamic Earth System, Prentice-Hall, New Delhi
16. Gass, I.G. (1982) Understanding the Earth, Artemis Press (Pvt) Ltd. U.K.
17. Moores, Eldridge M. and Twiss, Robert J. (1995) Tectonics, Freeman and Company.
18. Valdiya, K.S. (1984) Aspects of Tectonics -Focus on south central Asia, Tata McGraw- Hill.

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C203.1	Students will be able to identify geomorphic landforms.	**2**
C203.2	Students will be able to identify geological structures.	**2**
C203.3	Students will be able to prepare geological and Geomorphological maps, which is the prime requirement of any geological branches.	**3**

CORE COURSE	
GS-204: PRACTICALS RELATE TO IGNEOUS AND METAMORPHIC PETROLOGY	
	Course Objectives: 1. To provide hands on practice regarding identification and classification of igneous and metamorphic rocks using Megascopic and microscopic techniques. 2. To learn textures and structures of igneous rocks and metamorphic rocks. 3. To plot and interpret rock data using variation diagrams. 4. To develop a skill of rock identification using CIPW normative calculation
1	Megascopic study of Igneous rocks
2	Megascopic study of Metamorphic rocks
3	Microscopic study of Igneous rocks
4	Microscopic study of Metamorphic rocks
5	Characterization of Igneous rocks, Texture and structures
6	Characterization of Metamorphic rocks, structures/Textures
7	CIPW normative calculation for Igneous rocks
8	Niggli's form calculations
9	AFM form calculations
10	ACF form calculations
11	AKF form calculations
12	Variation Diagrams (Binary and Ternary)

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C204.1	Students will be able to identify different types of igneous, metamorphic rocks.	**2**
C204.2	Students will be able to operate of sophisticated instruments.	**3**
C204.3	Students will be able to plan their career in the field of petrology and related research.	**4**

CORE COURSE	
GS-205: PRACTICALS RELATED TO GEOMORPHOLOGY, STRUCTURAL GEOLOGY AND TECTONICS	
	Course Objectives: 1. To identify different landforms for depicting variation in terrain characteristics. 2. To calculate parameters of Drainage Morphometry and slope analysis for solving various geological problems. 3. To use Geomorphological knowledge in the field of geohydrology, mineral prospecting, engineering geology, watershed management, urban planning and environmental studies. 4. To solve structural problems for interpretation, analysis and identification of geological structures.
1	Structural problems by orthographic and stereographic methods.
2	Construction of structural sections and interpretation of geological maps.
3	Study of Topographical maps
4	Plotting and interpretation of mesoscopic structural data
5	Drainage basin and network morphometry
6	Relief and slope analysis - Profiles and maps
7	Identification of landforms on toposheets, aerial photographs and satellite images
8	Study of representative soil profiles
9	Determination of height of objects, dip of beds , slope and thickness of beds by parallax bar

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C205.1	Students will be able to identify different geomorphic landforms and geological structures.	**2**
C205.2	Students will be able to develop geological and Geomorphological maps.	**3**
C205.3	Students will be able to operate field related various types of instruments	**3**

M.Sc. Part I Semester II (Applied Geology): Audit Courses

	AC-201(A): Soft Skills **(Personality and Cultural Development Related Audit course; Practical; 2 Credits)** **(Optional: Campus-level)**	
	Course Objectives (CObs): • To inculcate different soft skills among students.	
Unit 1	**Introduction to soft skills** Formal definition, Elements of soft skills, Soft vs. Hard skills, Emotional quotient, Goal setting, life skills, Need for soft skills, Communication skills, Etiquettes& Mannerism.	**2 hrs.**
Unit 2	**Self-Assessment** Goal setting, SWOT analysis, attitude, moral values, self-confidence, etiquettes, non-verbal skills, achievements, positive attitude, positive thinking and self-esteem. Activity: The teacher should prepare a questionnaire which evaluate students in all the above areas and make them aware about these aspects.	**4 hrs.**
Unit 3	**Communication Skills** Types of communication: Verbal, Non-verbal, body language, gestures, postures, gait, dressing sense, facial expressions, peculiarity of speaker (habits). Rhetoric speech: Prepared speech (topics are given in advance, students get 10 minutes to prepare the speech and 5 minutes to deliver, Extempore speech (students deliver speeches spontaneously for 5 minutes each on a given topic), Storytelling (Each student narrates a fictional or real-life story for 5 minutes each), Oral review (Each student orally presents a review on a story or a book read by them) Drafting skills: Letter, Report & Resume writing, business letters, reading & listening skills Activity: The teacher should teach the students how to write the letter, report and build resume. The teacher should give proper format and layouts. Each student will write one formal letter, one report and a resume.	**8 hrs.**
Unit 4	**Formal Group Discussion, Personal Interview & Presentation skills** Topic comprehension, Content organization, Group speaking etiquettes, driving the discussion & skills. Preparation for personal interview: dress code, greeting the panel, crisp self-introduction, neatness, etiquettes, language tone, handling embarrassing & tricky questions, graceful closing. Activity: Each batch is divided into two groups of 12 to 14 students each. Two rounds of a GD for each group should be conducted and teacher should give them feedback. Mock interview are to be conducted.	**4 hrs.**
Unit 5	**Aptitude and analytical skills** Quantitative aptitude, Numerical reasoning, verbal reasoning, diagrammatic test, situational tests, logical thinking. Analytical skills: Definition, Types, problem solving	**8 hrs.**
Unit 6	**Life skills** Time management, critical thinking, sound and practical decision making by dealing with conflicts, stress management, leadership qualities Activity: The teacher can conduct a case study activity to train students for decision making skills. The teacher should conduct a session on stress management and guide students on how to manage stress. The teacher may conduct a stress relieving activity in the class. He/she may counsel students individually to know their problems and guide them on dealing with them effectively.	**4 hrs.**

Suggested readings:

1. Basics of Communication In English: Francis Sounderaj, MacMillan India Ltd.
2. English for Business Communication: Simon Sweeney, Cambridge University Press
3. An Introduction to Professional English and Soft Skills: Das, Cambridge University Press
4. Quantitative Aptitude: R.S. Agrawal

Course Outcomes (COts):

On completion of this course, the student will be able to:

COt No.	Course Outcomes	Cognitive level
AC201A.1	Identify their lacunas about some soft skills and try to overcome the same.	**2**
AC201A.2	Practice learned soft skills in real life and do their jobs more effectively.	**3**

AC-201(B): Practicing Sports Activities

(Personality and Cultural Development Related Audit course; Practical; 2 Credits)
(Optional: Campus-level)

Course Objectives (CObs):

- To motivate students towards sports and provide them required training.

SR NO.	NAME OF THE SPORT/GAME (Select ONE of the Following)	SYLLABUS OF THE COURSE	TIMING (02 Hours in a Week)	SEMESTER
1	Volleyball	• General Fitness • Basic Fitness • Specific Fitness • History of the Game • Basic Skill of the Game • Major Skill of the Game • Technique & Tactics of the Game • Game Practice	Morning : 07 to 09 AM OR Evening : 05 to 07 PM	Total 30 Hours in Each Semester
2	Athletics			
3	Badminton			
4	Cricket			
5	Basketball			
6	Handball			
7	Kabaddi			
8	Kho-Kho			
9	Table-Tennis			
10	Swimming			

Course Outcomes (COts):

On completion of this course, the student will be able to:

COt No.	Course Outcomes	Cognitive level
AC201B.1	Identify one or more sports of their choice and develop more interest to participate at University/National level sport events.	**2**
AC201B.2	Practice the learned sports activities regularly in real life.	**3**

AC-201(C): Practicing Yoga

(Personality and Cultural Development Related Audit course; Practical; (2 Credits)
(Optional: Campus-level)

Course Objectives:

- To motivate students towards yoga and provide them required training.

	• Yog: Meaning, Definition & Introduction, Objectives • Primary Introduction of Ashtanga Yoga • Preparation of Yogabhyas • Omkar Sadhana, Prayer, Guru Vandana • Sukshma Vyayamas • Suryanamaskar (12 Postures) • Asanas : ▪ Sitting (Baithaksthiti) - Vajrasana, Padmasan, Vakrasan, Ardha-Pashchimotanasanan ▪ Supine (Shayansthiti) - Uttan Padaasan(Ekpad/Dwipad), Pavanmuktasana, Viparitakarani Aasan, Khandarasan, Shavasana ▪ Prone (Viparitshayansthiti) - Vakrahasta, Bhujangasana, Saralhasta Bhujangasana, Shalabhasana(Ekpad/Dwipad), Makarasana ▪ Standing (Dhandsthiti) - Tadasana , TiryakTadasana, Virasana, Ardh Chakrasana • Primary Study of Swasana: Dirghaswasana, Santhaswasana, JaladSwasana - 6 Types • Pranayama : Anuloma-viloma, Bhramari

Course Outcomes (COts):

On completion of this course, the student will be able to:

COt No.	Course Outcomes	Cognitive level
AC201C.1	Identify and practice some Yoga asanas regularly in their life to remain healthy.	**2**
AC201C.2	Provide guidance and practice about Yoga to their friends, parents and relatives.	**3**

AC-201(D): Introduction to Indian Music (Personality and Cultural Development Related Audit course; Practical; 2 Credits) (Optional: Campus-level)	
	Course Objectives: • To motivate students towards Indian music and provide them minimum required training. .
	• Definition and brief about generation of Swar, Saptak, Thaat, Raag, Aavartan, Meend, Khatka, Murkee, Taal, Aalaap etc. • Taal and its uses - Treetaal, Daadraa, Zaptaal, Kervaa. • Information of Badaakhyaal, Chhotaakhyaal (one), Sargam, Lakshangeet (information) • Detailed information of Tambora • Detailed information of Harmonium and Tablaa. • Five filmy songs based on Indian Classical Music (Theory and Presentation) • Sound Management - Basic information of Sound Recording (including Practicals) • Composition of Music as per the Story • Preparing news write-ups of the Seminars, Library Musical Programmes held at the nearest Akashwani, by personal visits.

Course Outcomes (COts):
On completion of this course, the student will be able to:

COt No.	Course Outcomes	Cognitive level
AC201D.1	Identify different types of Indian music.	**3**
AC201D.2	Develop more interest to learn and practice Indian music.	**4**

M. Sc. PART II (APPLIED GEOLOGY) (SEMESTER – III and IV)

Distribution of Course papers for M. Sc. Part II Applied Geology

Subject Code	Title of the Paper		Duration (Hrs./Wk)	Max. Mark	Exam. Time (Hrs.)
M.Sc. Part II (Applied Geology)					
Semester III : Theory Courses					
GS-301	Indian Stratigraphy	Core course	04	100	03
GS- 302(A)	Indian Mineral Deposits, Exploration and Mining	Elective	04	100	03
GS- 302(B)	**Nuclear Geology**	**Elective**	04	100	03
GS-303	Remote sensing and GIS	Core course	04	100	03
Semester III : Practical Courses					
GS-304	Practicals related to Remote sensing and GIS	Core course	**04+04**	**100**	**06**
GS-305	Practicals related to Indian stratigraphy, Indian Mineral Deposits, Exploration and Mining	Core course	**04+04**	**100**	**06**
AC-301 A/B/ C/D	**AC-301 A:** Computer Skills (T)/ **AC-301 B:** Cyber Security / **AC-301 C:** Rainwater Harvesting and /**AC-301 D:** Geo-tourism	Audit Course	**02**	**100**	
Semester IV : Theory Courses					
GS-401	Hydrogeology	Core course	**04**	**100**	**03**
GS- 402(A)	Petroleum Geosciences	Elective	**04**	**100**	**03**
GS- 402(B)	**Advanced Surveying in Geosciences**	Elective	04	100	03
GS- 403	Engineering and Environmental Geosciences	Core course	04	100	03
Semester IV : Practical Courses					
GS-404	Practicals related to Petroleum geosciences and Hydrogeology	Core course	**04+04**	**100**	**06**
GS-405	Dissertation/ Internship	Core course	04+04	100	06
AC-401 A/ AC-401 B/ AC-401 C / AC-401 D	**AC-401 A:** Human Rights/ **AC-401 B:** Current Affairs/ **AC-401 C:** Medical Geology/ **AC-401 D:** Watershed Management	Audit Course	**02**	**100**	

SEMESTER III

CORE COURSE		
GS-301: INDIAN STRATIGRAPHY		
	Course Objectives: 1. To learn the phenomenon, concept and principles of Indian Stratigraphy. 2. To learn the different types of Mobile Belts in Indian Stratigraphy. 3. To learn Proterozoics of Peninsular India. 4. To learn World Stratigraphy along with Geological Time Scale.	
Unit 1	**Archeans** 1. Tectonic framework of India – Cratons and Mobile Belts 2. Dharwar Craton EDC and WDC (Gold Bering Schist belts and Iron Ore Group) 3. Singbhum Craton (OMG, OMTG and Iron Ore Group) 4. Baster Craton (Sukma, Bengpal and Bailadila Series) 5. Arvalli Craton (BGC, Sandmata Complex, Bhiwara Super group) 6. Budelkhand (Supracrustal Gneisses and Budelkhand Granite)	**15 L**
Unit 2	**Mobile Belts** 1. Satpura Mobile Belts 2. Pandyan Mobile Belts 3. Easter Ghats Mobile Belts (Charnockite and Khondalite)	**10 L**
Unit 3	**Proterozoics of Peninsular India** 1. Delhi Super Group 2. Vidhayan Super Group 3. Cuddapah Super Group 4. Sausar- Sakoli Group 5. Kaladgi Group Bhima 6. Pranhita-Godavari Group	**15 L**
Unit 4	**Phanerozoic Stratigraphy of India** 1. Ophiolite Belt (Indus, Shayok, Trans- Himalaya and Karakoram Batholiths) 2. Stratigraphic and Tectonics of Siwalik 3. Stratigraphic and Tectonics of Spiti Valley 4. Gondwana Super Group 5. Deccan Volcanic Province (DVP) 6. Marine transgression and regression	**10 L**
Unit 5	**Recent Geology** 1. Cenozoic Geology of India 2. Quaternary Sediments 3. World stratigraphy – Time Scale and geologic events	**10 L**

Suggested readings:

1. Battey, M.H. (1981) Mineralogy for students 2nd Edn. Longmans.
2. Boggs, S. (2001) Principles of Sedimentology and Stratigraphy, Prentice Hall.
3. Danbar, C.O. and Rodgers, J. (1957) Principles of Stratigraphy, John Wiley and Sons.
4. Doyle, P. and Bennett. M.R. (1996) Unlocking the Stratigraphic Record, John Wiley and Sons.
5. Krishnan,M.S. (1982) Geology of India and Burma, C.B.S. Publ. and Distributors, Delhi.
6. Naqvi, S.M. and Rogers, J.J.W. (1987) Precambrian Geology of India, Oxford University Press.
7. Pascoe, E.H. (1968) A Manual of the Geology of India and Burma (Vols.I-IV), Govt. of India Press, Delhi.
8. Pomerol, C. (1982) The Cenozoic Era: Tertiary and Quaternary, Ellis Harwood Ltd., Halsted Press.
9. Schoch, Robert, M. (1989) Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York.
10. Ramakrishnan, M. and Vaidyanadhan, R. (2008) Geology of India, Vol.1, Geological Society of India, Bangalore.
11. Vaidyanadhan, R. and Ramakrishnan, M. (2008) Geology of India, Vol.2, Geological Society of India,Bangalore.

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C301.1	Students will be able to correlate lithounits in relation to the Geological Time scale.	**4**
C301.2	Students will be able to correlate different type of rock succession occurs in India.	**4**
C301.3	Students will be able to correlate minerals origin with geologic time.	**4**

ELECTIVE COURSE		
GS-302 (A): INDIAN MINERAL DEPOSITS, EXPLORATION AND MINING		
	Course Objectives: 1. To learn the phenomenon, concepts of Ore genesis. 2. To learn the different types of Mineral exploration Techniques. 3. To learn occurrence and distribution in India of Metalliferous deposits. 4. Too learn Classification, Genesis and Distribution of coal fields in India.	

Unit 1	**Ore Genesis:** 1. Ore bearing fluid, Fluid inclusion studies, Ore deposits and ore minerals 2. Metallogenic Epochs and Proviences 3. Magmatic processes of mineralization, Porphyry, Skarn and hydrothermal mineralization, Ores and metamorphism- cause and effect relations, Stratiform and Stratabound ores 4. Mineralization associated with – (i) Ultramafic, mafic and acidic rocks (ii) Greenstone belts (iii) Komatites, Anorthosites and Kimberlites (iv) Submarine volcanism	**10 L**
Unit 2	**Indian Mineral Deposits:** 1. Occurrence and distribution in India of metalliferous deposits – base metals, iron, manganese, aluminum, chromium, nickel, gold, silver and molybdenum 2. Indian deposits of non-metals – mica, asbestos, barites, gypsum, graphite, apatite and beryl, Gemstones, refractory minerals, abrasives and minerals used in glass, fertilizer, paint, ceramic and cement industries, Building stones, Phosphorite deposits, Placer deposits and rare earth minerals	**15 L**
Unit 3	**Indian Coal deposits and Mineral Economics:** 1. Coal deposits: Classification, genesis and distribution of coal fields in India 2. Strategic, critical and essential minerals 3. India's status in mineral production changing patterns of minerals consumption, National Mineral Policy 4. Mineral Concession Rules, Marine mineral resources and Law of sea	**15 L**
Unit 4	**Mineral exploration:** 1. Surface and subsurface exploration techniques 2. Guides to ore: Regional and Topographical Guides, Mineralogical Guides Structural Guides and Stratigraphic Guides 3. Prospecting for economic minerals – drilling, sampling and assaying 4. Geophysical techniques – gravity, electrical, magnetic, airborne and seismic geophysical techniques 5. Geomorphological and remote sensing techniques 6. Geobotanical and geochemical methods 7. Geochemical prospecting	**10 L**

Unit 5	**Drilling, Logging and Mining:** 1. Drilling Methods: Percussion Drills – Jumper bar drills- Pneumatic drills - Churn drills- Reich drills, Rotary Drills -Auger drills- Calyx drills-Turbo drills- Diamond drills 2. Borehole logging and surveys for deviation 3. Mining Methods - Alluvial Mining- Open Cast Mining Underground Mining	**10 L**

Suggested readings:

1. Boardman, R.S., Cheethan, A.M. and Rowell, A.J. (1988) Fossil Invertebrates, Blackwell.
2. Geochemistry In Mineral Exploration Awakes, H & Wobb J.S. Harper & Row New York.
3. Principles Of Geochemical Prospecting, Ginsburg. I.I. Pentagon Press, N.Y. london.
4. Geochemistry Of Rare And Dispersed Chemical Elements In Society, Vinogradev.
5. Biochemical Methods Of Prospecting, Malyuga, D.P.
6. Geochemistry Of Epigenesis - Faibidge.
7. Principles of Mining Geology, Arogyaswamy.
8. Introduction To Geophysical Prospecting - Milton B, Dobrin Mc-Graw Hill Book Company, Inc
9. Exploraion Geophysics - Jakaosku, J.J.
10. Outlines Of Geophysical Prospecting - A manual for Geologists. M.B.R. Rao. Prasaranga, Mysore University
11. Geophysical Methods in Geology - P.V. Sharma.
12. Applied Geophysics In The Search For Minerals - Eve. A.S.Keys.
13. Geophysical Exploration - Heilava. C.H.
14. Exploration Geophysics for Geologists And Engineers - Edited by Bhimasanakaran, V.L.S. Gour. V.K. - The Association of Exploration Geophysists – Hyderabad
15. Principles of Applied Geophysics - D.S. Parasnis
16. Introduction to Geophysics -C.H.Howel.
17. The Geology Of Ore Deposits - John M. Guilbert and charles. F.Park, Jr.W.H.Freeman and Co., New York. 1986.
18. Economic Mineral Deposits, Bateman, A.M.
19. Ore Deposits - Park, Jr. C.F.
20. Geology Of Mineral Deposits - Smirnov, U.J.
21. The Ore Minerals And Their Intergrowths - Ramhor, Dr. Paul.
22. Ore Petrology - Stanton, R.L.
23. India's Mineral Resources - Krishnaswamy, S.
24. Metallic and Industrial minerals - Lamey Carl, A.
25. Introduction To India's Economic Minerals - Sharma, N.L. & Ram. K. S.
26. A Treatise On Industrial Minerals Of India-Sinha, R.L.
27. Mineral Deposits Of India, Mukerjee 1999: Allied publications.

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C302 (A).1	Students will be able to identify different types Surface and subsurface Mineral Exploration Techniques.	**2**
C302 (A).2	Students will able to discover occurrence and distribution of Indian Mineral Deposits.	**2**
C302 (A).3	Students will able to plan their career in the field of Mineral Exploration and Mining Sector.	**3**

ELECTIVE COURSE

GS-302 (B): NUCLEAR GEOLOGY

Course Objectives:

1. To learn basic concepts, Phenomenon of Geochemistry and Nucleus physics.
2. To learn applications of Isotopes in field of Geochronology.
3. To learn various dating methods used in Petroleum Geochemistry.
4. To learn basic concepts of Isotope cosmochemistry.

Unit 1	**Introduction And The Physics Of The Nucleus** 1. Geochemistry, The K-Ca-Ar system - The K-Ar and Rb-Sr systems 2. The Sm-Nd system - The UTh-Pb system 3. The U-Th-Pb system: Zircon dating 4. U-Th decay series dating - Other decay systems	**10 L**
Unit 2	**Isotopes In Geochronology** 1. Fission Track Dating - analytical Methods 2. Radiogenic isotope geochemistry - The Mantle the Pb Picture. Mantle Models Mantle Plumes. Subcontinental lithosphere 3. The continental crust. Isotope Geochemistry of subduction zone Magmas - isotope Cosmo chemistry 4. Evolution of the atmosphere and cosmogenic radionuclides	**15 L**
Unit 3	**Stable Isotope Geochemistry** 1. Stable Isotope Theory: Equilibrium fractionations - kinetic fractionations Hydrologic system, biological system 2. Fractionations of stable isotopes. Stable isotope applications 3. Assimilations fractional crystallization - Assimilation and subduction-hydrothermal Activity 4. Metamorphism and ore deposits	**15 L**
Unit 4	**Stable Isotopes And Applications In Paleoclimate Study** 1. Paleontology and Archaeology, 2. Application to paleoclimatology-deep sea, continental records. 3. The Carbon Cycle, Isotopes and climate tree ring studies	**10 L**
Unit 5	**Carbon Isotope And Petroleum Geochemistry** 1. Sulphur isotopes 2. Diffusion experiments in isotope geology with case studies	**10 L**

Suggested readings:

1. Fraure, G, Principles of isotope geology, John Wiley, Second edition. 1986.
2. Bradely, R.S, Quaternary paleoclimatology, methods of paleoclimatic reconstruction, Allen and Unwin Inc., US, 1985.

3. Criss, R.E. Pricinciples of stable Isotope distributions. Oxford University press, 1999.
4. Lajtha, J. and Michener, R. Stable isotopes in ecology and environmental Science, Blackwell, 1994.
5. Griffiths, K., Stable Isotopes: Interpretation of biological, ecological and geochemical processes, 1998.

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C302 (B).1	Students will be able to apply Isotopes in field of Petroleum, Geochronoloy and Geochemistry.	**3**
C302 (B).2	Students will be able to conclude role of nuclear geology in study of paleoclimatic condition of rock formation.	**4**
C302 (B).3	Students will be able to plan their career in the field of atomic Research.	**4**

CORE COURSE		
GS-303: REMOTE SENSING AND GIS		
	Course Objectives: 1. To learn Principles, concepts and Fundamentals of Remote Sensing. 2. To learn and types of sensors and data resolution. 3. To learn Visual photo interpretation techniques based on photo elements and terrain elements. 4. To learn about Indian Space missions and Principles of Global Positioning System. 5. To learn basic concepts, fundamentals of Geographic Information System.	
Unit 1	**Fundamentals of Remote Sensing** 1. Concepts and principles of Remote Sensing 2. The nature and generation of EMR 3. Interaction of EMR with the atmosphere and earth's surface features. 4. Visual photo interpretation techniques based on 'photo elements' and 'terrain elements'	**10 L**
Unit 2	**Satellite Remote Sensing:** 1. Satellite Remote Sensing – Data products and their specifications 2. Remote Sensing observations and platforms 3. Types of sensors, Data Resolution 4. Global and Indian Space missions 5. Multispectral and Hyperspectral Remote Sensing	**15 L**

Unit 3	**Digital Image Processing and Image Interpretation** 1. Digital Image Structure and Data recording formats 2. Image rectification and restoration 3. Spectral Signatures 4. Image enhancement and classification 5. Image transformation and data fusion 6. Ground truths and training sets in image processing and in automated processing	**15 L**
Unit 4	**Thermal and Microwave Remote Sensing** 1. Thermal properties of materials 2. Thermal IR Detection and Imaging 3. Microwave Sensors 4. Applications of Thermal and Microwave Remote Sensing	**10 L**
Unit 5	**Geographic Information Systems (GIS)** 1. Principles and applications of GIS 2. Map Projections Systems, Map Visualization 3. Traditional maps, map scales and their interpretation 4. Components of GIS, GIS data models and structures 5. Thematic Mapping 6. GIS analysis and GIS modeling	**10 L**
	7. Integration of Remote sensing and GIS techniques and it's applications in Geological Sciences 8. Principles and applications of GPS	

Suggested readings:

1. Lattman, L.H. and Ray, R.G. (1965) Aerial photographs in field geology, McGraw Hill.
2. Pande, S.N. (1987) Principles and Applications of Photogeology, Wiley Eastern Limited.
3. Drury, S.A. (1997, 2001) Image Interpretation in Geology, Chapman and Hall, London.
4. Gupta, R.P. (1991) Remote Sensing Geology, Springer-Verlag.
5. Lillesand, T.M. and Kiefer, R.W. (2000) Remote Sensing and Image Interpretation, John Wiley and Sons Inc., New York.
6. Siegal, B.S. and Gillespie, A.R. (1980) Remote Sensing in Geology, John Wiley. Ray, R.G. (1969) Aeriat Photographs in Geologic Interpretations, USGS Proc Paper 373
7. Mikhail, E.M. (1980) Photogrammatry, Harper and Row
8. Paine, D.P. (1981) Aerial photography and Image Interpretation for Resource Management, JohnWiley.
6. Miller, V.C. (1961) Phologeology, McGraw Hill
7. Sabins, F.F. Jr. (2000) Remote Sensing Principles and Interpretations, W.H. Freeman & Company, USA.
9. Berhardsen, T. (1999) Geographic Information System: an introduction, Wiley, New York. Curran, P.J. (1985) Principles of Remote Sensing, Longman Scientific & Tech. Group, Essex, England Jensen, J.R. (1986) Introductory Digital Image Processing: A Remote Perspective. Prentice Hall, New Jersy.
10. Jain, A.K. (1989) Fundamentals of digital image processing, Prentice Hall India.
11. Bonham-Carter, G.F. (1994) Geographic Information System for Geoscientists: Modelling with GIS, Pergamon.
12. Maguire, D.J., Goodchild, M.F. and Rhind, D.W. (1991) GIS - Principles and Applications, Longman Scientific and Technical. Ray, R.G. (1969) Aeriat Photographs in Geologic Interpretations, USGS Proc Paper 373

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C303.1	Students will be able to summarize principles, fundamental concepts of remote sensing and GPS.	**5**
C303.2	Students will be able to summarize Principles, fundamental concepts of Geographic Information System.	**5**
C303.3	Students will be able to plan their career in the field of Geospatial Technology.	**4**

CORE COURSE	
GS-304: PRACTICALS RELATED TO REMOTE SENSING AND GIS	
	Course Objectives: 1. To learn generation of different thematic maps in GIS. 2. To construct flow charts for the computer programs required in solving Geoscientific problems. 3. To learn the visual interpretation of earths features from aerial photographs and satellite images. 4. To learn different types of satellite data.
1	Determination of photo scale
2	Study of traditional maps
3	Visual interpretation of earth's features from aerial photographs and satellite images
4	Stereo-photo interpretation
5	Photogrametric computation
6	Preparation of different thematic maps in GIS
7	Operation of Global positioning system (GPS)
8	Drawing flow charts for the computer programs required in solving Geo-scientific Problems
9	Study of Different Satellite Images and its processing.

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C304.1	Students will be able to summarize Principles, fundamental concepts of remote sensing and GPS.	5
C304.2	Students will be able to judge with various satellite data.	4
C304.3	Students will be able to prepare various types of thematic maps and related work.	3

CORE COURSE	
GS-305: PRACTICALS RELATED TO INDIAN STRATIGRAPHY, MINERAL DEPOSITS, EXPLORATION AND MINING	
	Course Objectives: 1. To learn construction of structural sections and interpretation of Geological maps. 2. To learn preparation of technical report regarding economically important minerals. 3. To learn different types of economic evaluation of ore minerals. 4. To learn the identification of Metallic and non-metallic economic minerals and prepare technical reports.
1	Delineation of ore deposits based on exploration data
2	Economic evaluation of ore deposits
3	Preparation of technical report
4	Geochemical map interpretation, Interpretation of anomalies groundwater and river water, selection of geochemical methods in mineral exploration
5	Interpretation of field geophysical data gravity, Magnetic, Electrical, Seismic and radio active in deciphering groundwater, mineralized zones and construction site evaluation
6	Study of Metallic economic minerals
7	Study of Non-metallic economic minerals
9	Study of Indian Ore Minerals

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C305.1	Students will be able to identify different types of Metallic and non-metallic economic minerals.	**2**
C305.2	Students will be able to prepare of ore deposits based on exploration data.	**3**
C305.3	Students will able to prepare technical report form geophysical data gravity, Magnetic, Electric, Seismic data and they will able to economic evaluation of ore deposits.	**3**

M.Sc. Part II Semester III (Applied Geology): Audit Courses

AC-301(A): Computer Skills (Technology + Value added Audit course; Practical; 2 Credits) (Optional: Campus + Program level)		
Course Objectives (CObs): • To inculcate different daily useful computer skills among students.		
Unit 1	**Elements of Information Technology** ❖ Information Types: Text, Audio, Video, and Image, storage formats ❖ Components: Operating System, Hardware and Software, firmware ❖ Devices: Computer, Mobile Phones, Tablet, Touch Screen, Scanner, Printer, Projector,smart boards ❖ Processor & Memory: Processor functions, speed, Memory types: RAM /ROM /HDD /DVD-ROM/Flash drives, memory measurement metrics	**2 hrs**
Unit 2	**Office Automation-Text Processing**	**5 hrs**

	❖ Views: Normal View, Web Layout View, Print Layout View, Outline View, ReadingLayout View ❖ Working with Files: Create New Documents, Open Existing Documents, SaveDocuments to different formats, Rename Documents, Close Documents ❖ Working with Text: Type and Insert Text, Highlight Text, Formatting Text, Delete Text,Spelling and Grammar, paragraphs, indentation, margins ❖ Lists: Bulleted and Numbered Lists, ❖ Tables: Insert Tables, Draw Tables, Nested Tables, Insert Rows and Columns, Moveand Resize Tables, Moving the order of the column and/or rows inside a table, TableProperties ❖ Page Margins, Gutter Margins, Indentations, Columns, Graphics, Print Documents, ❖ Paragraph Formatting, Paragraph Attributes, Non-printing characters ❖ Types of document files: RTF, PDF, DOCX etc.	
Unit 3	**Office Automation-Worksheet Data Processing** 3.1 Spreadsheet Basics: Adding and Renaming Worksheets, Modifying Worksheets, 3.2 Moving Through Cells, Adding Rows, Columns, and Cells, Resizing Rows and Columns, Selecting Cells, Moving and Copying Cells 3.3 Formulas and Functions: Formulas, Linking Worksheets, Basic Functions, AutoSum, Sorting and Filtering: Basic Sorts, Complex Sorts, Auto-fill, Deleting Rows, Columns, and Cells 3.4 Charting: Chart Types, drawing charts, Ranges, formatting charts	**5 hrs**
Unit 4	**fice Automation- Presentation Techniques and slide shows** 4.1 Create a new presentation, AutoContent Wizard, Design Template, Blank Presentation,Open an Existing Presentation, PowerPoint screen, Screen Layout 4.2 Working with slides: Insert a new slide, Notes, Slide layout, Apply a design template,Reorder Slides, Hide Slides, Hide Slide text, Add content, resize a placeholder or textbox, Move a placeholder or text box, Delete a placeholder or text box, Placeholder orText box properties, Bulleted and numbered lists, Adding notes 4.3 Work with text: Add text and edit options, Format text, Copy text formatting, Replacefonts, Line spacing, Change case, Spelling check, Spelling options 4.4 Working with tables: Adding a table, Entering text, Deleting a table, Changing rowwidth, Adding a row/column, Deleting a row/column, Combining cells ,Splitting a cell,Adding color to cells, To align text vertically in cells, To change table borders,Graphics, Add clip art, Add an image from a file, Save & Print, slide shows, slideanimation/transitions.	**6 hrs**
Unit 5	**ernet & Applications:** 5.1 Computer Network Types: LAN, PAN, MAN, CAN, WAN, Defining and describing theInternet, Brief history, Browsing the Web, Hypertext and hyperlinks, browsers,Uniform resource locator 5.2 Internet Resources: Email, Parts of email, 5.3 Protecting the computer: Password protection, Viruses, Virus protection software,Updating the software, Scanning files, Net banking precautions. 5.4 Social Networking: Features, Social impact, emerging trends, issues, Social Networking sites: Facebook, Twitter, linkedin, orkut, online booking services 5.5 Online Resources: Wikipedia, Blog, Job portals, C.V. writing 5.6 e-learning: e-Books, e-Magazines, e-News papers, OCW(open course wares): Sakshat(NPTEL) portal, MIT courseware	**4 hrs**
Unit 6	**Cloud Computing Basics** 6.1 Introduction to cloud computing 6.2 Cloud computing models: SAS, AAS, PAS 6.3 Examples of SAS, AAS, PAS (DropBox, Google Drive, Google Docs, Office 365 Prezi, etc.)	**3 hrs**

Suggested readings:

1. TCI, "Introduction to Computers and Application Software", Publisher: Jones & Bartlett Learning, 2010, ISBN: 1449609821, 9781449609825
2. Laura Story, Dawna Walls, "Microsoft Office 2010 Fundamentals", Publisher: Cengage Learning, 2010, ISBN: 0538472464, 9780538472463
3. June Jamrich Parsons, Dan Oja, "Computer Concepts Illustrated series", Edition 5, Publisher Course Technology, 2005, ISBN 0619273550, 9780619273552
4. Cloud computing online resources

Course Outcomes (COts):

On completion of this course, the student will be able to:

COt No.	Course Outcomes	Cognitive level
AC301A.1	Identify their lacunas about some computer skills and try to overcome the same.	**2**
AC301A.2	Practice the learned computer skills in real life and do their jobs more effectively.	**3**

AC-301(B): Cyber Security

(Technology + Value added Audit course; Practical; 2 Credits)

(Optional: Campus + Program level)

Course Objectives (CObs):

- To make students aware of different daily useful cyber security skills/rules.

Unit 1	**tworking Concepts Overview** sics of Communication Systems, Transmission Media, ISO/OSI and TCP/IP models, Network types: Local Area Networks, Wide Area Networks, Internetworking, Packet Formats, Wireless Networks: Wireless concepts, Advantages of Wireless, Wireless network architecture, Reasons to use wireless, Internet	**3 hrs**
Unit 2	**curity Concepts** ormation Security Overview, Information Security Services, Types of Attacks, Goals for Security, E-commerce Security, Computer Forensics, Steganography. portance of Physical Security, Biometric security & its types, Risk associated with improper physical access, Physical Security equipments. sswords: Define passwords, Types of passwords, Passwords Storage – Windows & Linux.	**7 hrs**
Unit 3	**curity Threats and vulnerabilities** erview of Security threats, Hacking Techniques, Password Cracking, Types of password attacks, Insecure Network connections, Wi-Fi attacks & countermeasures, Information Warfare and Surveillance. ber crime: e-mail related cyber crimes, Social network related cyber crimes, Desktop related cyber crimes, Social Engineering related cyber crimes, Network related cyber crimes, Cyber terrorism, Banking crimes	**7 hrs**
Unit 4	**yptography** derstanding cryptography, Goals of cryptography, Types of cryptography, Applications of Cryptography, Use of Hash function in cryptography, Digital signature in cryptography, Public Key infrastructure	**5 hrs**
Unit 5	**stem & Network Security** stem Security: Desktop Security, email security: PGP and SMIME, Web Security: web authentication, Security certificates, SSL and SET, Network Security: Overview of IDS, Intrusion Detection Systems and Intrusion Prevention Systems, Overview of Firewalls, Types of Firewalls, VPN Security, Security in Multimedia Networks, Fax Security.	**3 hrs**
Unit 6	**Security** Security Vulnerabilities updates and patches, OS integrity checks, Anti-virus software, Design of secure OS and OS hardening, configuring the OS for security, Trusted OS.	**2 hrs**
Unit 7	**curity Laws and Standards** curity laws genesis, International Scenario, Security Audit, IT Act 2000 and its amendments.	**3 hrs**

Suggested readings:

1. Skills Factory, Certificate in Cyber Security, Text Book Special edition, Specially published for KBC NMU, Jalgaon
2. BPB Publication, "Fundamentals of Cyber Security", Mayank Bhushan, Rajkumar Singh Rathore , Aatif Jamshed
3. CreateSpace Independent Publishing Platform, "Cyber Security Basics", Don Franke, ISBN-13: 978-1522952190ISBN-10: 1522952195
4. Online references

Course Outcomes (COts):
On completion of this course, the student will be able to:

COt No.	Course Outcomes	Cognitive level
AC301B.1	Practice learned cyber security skills/rules in real life.	**3**
AC301B.2	Provide guidance about cyber security skills/rules to their friends, parents and relatives.	**2**

AC-301(C): RAINWATER HARVESTING **(Technology + Value added Audit course; Practical; 2 Credits)** **(Optional: Campus + Program level)**	
Course Objectives (CObs): **1.** To make students aware of water scarcity and individuals' role to save and conserve the most precious water resource.	
CONTENT OF THE SYLLABUS	
1.	Water – Science & Hydrology
2.	Integrated Water Resource Management
3.	Water Harvesting Techniques & Management
4.	**DEMONSTRATION:** Demonstration of Success stories, Practicing Rainwater Harvesting and visit to Rainwater Harvesting structure.

Course Outcomes:
On completion of this course, the student will be able to:

COt No.	Course Outcomes	Cognitive level
AC301C.1	Practice learned on field rainwater harvesting.	**3**
AC301C.2	Provide guidance about awareness about importance of harvesting to local community	**2**

AC-301(D): GEO-TOURISM **(Value added Audit course; Practical; 2 Credits)** **(Optional: Campus + Program level)**	
Course Objectives (CObs): **1.** To aware students about the geological tourist spots present around their areas.	
CONTENT OF THE SYLLABUS	
1.	The concepts: tourism; the importance of Nature and Geodiversity in Geotourism; geoheritage and natural heritage
2.	Strategies and tools for Nature Conservation
3.	The National Network of Protected Areas, Geoparks and Natural Monuments
4.	Case study/ Project work and Report
5.	Geotourist routes: inventory, evaluation, conservation, and enhancement of natural heritage
6.	**ASSIGNMENT:** Assignment to evaluate the potential of given tourism site. Students has to study and submit report on site.

Course Outcomes:
On completion of this course, the student will be able to:

COt No.	Course Outcomes	Cognitive level
AC301D.1	Practice learned importance of conservation of geologically important sites	**3**
AC304D.2	Provide guidance about awareness about importance of geological sites to local community	**2**

SEMESTER – IV

CORE COURSE		
GS-401: HYDROGEOLOGY		
	Course Objectives: 1. To learn the phenomenon, concept Hydrogeology. 2. To learn the various factors that affect occurrence of Groundwater. 3. To learn Hydrologic properties of rock and Hydrological classification of rocks. 4. To learn the water audit and its significance. 5. To learn the various groundwater exploration techniques and watershed management and development.	
Unit 1	**Introduction** 1. Hydrosphere – Hydrological Cycle, Evaporation, condensation, precipitation, interception, runoff cycle (surface, subsurface and groundwater), infiltration 2. Factors that affect occurrence of groundwater – Climate, topography and geology 3. Hydrogeological classification of rocks 4. Constraints of water resources 5. Hydrologic properties of Rocks – Porosity, Hydraulic conductivity 6. Derivation and validation of Darcy's Law 7. Aquifers – Characteristics of unconfined and confined aquifers 8. Behavior of alluvium, sedimentary, crystalline and volcanic rocks as aquifers	**10 L**
Unit 2	**Wells and Pumping tests** 1. Types of well 2. Flow net analysis 3. Pumping tests – principles – types of pumping tests, procedures, determination of aquifer properties and well characteristics by simple graphical methods 4. Significance of Transmissivity, Storativity and specific capacity of wells. 5. Water Audit and its significance	**15 L**
Unit 3	**Groundwater quality and Aquifer Mapping** 1. Quality of groundwater – chemical standards for drinking and irrigational water- concept of hydro-geochemical facies 2. Seawater intrusion – Ghyben Herzberg relation – remedial measures 3. Environmental interpretation of quality data and its impact 4. Concept Aquifer Mapping, Methodology, Techniques and Model Study.	**15 L**

Unit 4	**Exploration techniques** 1. Integrated approach to groundwater prospecting: Role of toposheets and remote sensing in groundwater exploration 2. Hydro-geomorphological mapping 3. Surface and subsurface Geophysical methods 4. Tracer techniques Exploratory Bore well programme 5. Type of Groundwater Investigation Processes	**10 L**
Unit 5	**Watershed Development and management** 1. Introduction to Watershed development: Artificial recharge techniques, surface water harvesting techniques 2. Conjunctive use of groundwater 3. Groundwater provinces of India 4. Groundwater in Maharashtra state 5. Groundwater legislation	**10 L**

Suggested readings:

1. Davies, S.N. and De Wiest, R.J.N. (1966) Hydrogeology, John Wiley and Sons, New York.
2. Driscoll, F.G. (1988) Groundwater and Wells, UOP, Johnson Div. St. Paul. Min. USA.
3. Karanth, K. R. (1989) Hydrogeology, Tata McGraw Hill Publishers.
4. Nagabhushaniah, H.S. (2001) Groundwater in Hydrosphere (Groundwater hydrology), CBS Publ.
5. Raghunath, H.M. (1990) Groundwater, Wiley Eastern Ltd.,
6. Todd, D.K. (1995) Groundwater Hydrology, John Wiley and Sons.
7. Tolman, C.F. (1937) Groundwater, McGraw Hill, New York and London.

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C401.1	Students will be able to identify different types of Groundwater exploration techniques.	**2**
C401.2	Students will be able to do hydrological classification of rocks.	**4**
C401.3	Students will be able to plan their career in the field of Groundwater exploration, Hydrology and Hydrogeology.	**4**

ELECTIVE COURSE		
GS-402 (A): PETROLEUM GEOSCIENCES		
	Course Objectives: 1. To learn basic concepts of Petroleum Geosciences. 2. To learn composition of reservoir and source rocks. 3. To learn surface and subsurface occurrence of hydrocarbans. 4. To learn the drilling techniques uses for exploration of petroleum and gas. 5. To learn about petroliferous basins in world and India.	
Unit 1	**Composition of Reservoir and Source rocks** 1. Composition of hydrocarbons & non hydrocarbons component 2. Physico-chemical properties of hydrocarbons (oil, gas, oil field waters, Coal bed methane, hydrates) 3. Surface & subsurface occurrences of hydrocarbons 4. Theories of Organic and inorganic Origin of hydrocarbons: Merits & De-merits 5. Organic petroleum geochemistry and conversion of organic matter into hydrocarbons 6. Kerogen : Composition, classification and types 7. Source & reservoir rocks (porosity & permeability); petroliferous basins	**10 L**
Unit 2	**Petroleum Systems** 1. Limestone Classification 2. Migration-Primary & Secondary, characteristics & processes 3. Accumulation: Favorable & unfavorable conditions; nature of accumulation 4. Clastic and Non-clastic Reservoirs rocks 5. Traps: introduction, conditions of formation and Types 6. Introduction to Oil-Water, Gas-Oil Contacts 7. Fluid flow within Reservoirs	**15 L**
Unit 3	**Exploration & Logging** 1. Introduction to Geophysical 2. Logging: Introduction, Types & Interpretation. 3. Seismic methods: Principles, techniques, tools and interpretation 4. Electrical logs: Principles, techniques, tools and interpretation 5. Gamma ray & neutron logs: Principles, techniques, tools and interpretation	**15 L**
Unit 4	**Drilling Techniques** 1. Introduction to Drilling methods, 2. Rigs and their types used in oil exploration 3. Component of Rigs & Drilling Mechanism. 4. Drilling and mud parameters 5. Enhance Oil Recovery (EOR): Primary, Secondary & Tertiary	**10 L**

Unit 5	**Petroliferous basins** 1. World scenario and at least one case study of economically important Hydrocarbon deposits; 2. Petroliferous basins of India 3. Stratigraphy, lithology, structure and reserve estimation of – Bombay high, Krishna Godavari, Assam, Cambay and Jaisalmer Basins	**10 L**

Suggested readings:

1. Leverson, A.L. (1970) Geology of Petroleum, Freeman and Company.
2. North, F.K. (1985) Petroleum Geology, Allen and Unwin.
3. Holson, G.D. and Tiratsoo, E.N. (1985) Introduction to Petroleum Geology, Gulf Publ. Houston, Texas.
4. Tissot, B.P. and Welte, D.H. (1984) Petroleum Formation and Occurrence, Springer- Verlag.
5. Selley, R.G. (1998) Elements of Petroleum Geology, Academic Press.
6. Russel : Petroleum Geology
7. Primer of Oil well drilling : By IADC
8. Bhagwan Sahay : Mud logging
9. Person : Geological Well drilling technology
10. Cray and Cole : Oil & well drilling technology
11. Kennedy : Fundamentals of Drilling
12. Hearst & Nelson : Well logging for physical properties
13. Killops & Killops (200) Organic Geochemistry
14. F. K North Petroleum Geology

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C402(A).1	Students will be able to summarize basic concepts of petroleum geosciences.	**5**
C402(A).2	Students will get to summarize various drilling techniques used in exploration of oil and gas.	**5**
C402(A).3	Students to use this knowledge in plan their career in field of Oil and Gas sector.	**4**

ELECTIVE COURSE		
GS-402 (B): ADVANCED SURVEYING IN GEOSCIENCES		
	Course Objectives: 1. To learn basic concepts of Surveying useful in Geosciences. 2. To learn use and components of Advance survey Instruments. 3. To learn type and uses of Theodolite, Plane table surveys. 4. To learn the principles of tacheometry, tacheometer an its components.	
Unit 1	**Plane Table Surveying** 1. Principle of plane table survey 2. Accessories of plane table and their use, Telescopic alidade 3. Methods of plane table surveys- Radiation, Intersection and Traversing 4. Merit and demerits of plane table survey	**10 L**
Unit 2	**Theodolite survey** 1. Types and uses of Theodolite, Component parts of Transit Theodolite and their functions, Reading the Vernier of transit theodolite. 2. Technical terms- Swinging, Transiting, Face left, Face right 3. Check for open and closed traverse, calculations of bearing from angles	**15 L**
Unit 3	**Tacheometry** 1. Principal of tacheometry, Tacheometer, and its components parts, Analytic lens 2. Tacheometric formula for horizontal distance with telescope horizontal and staff vertical 3. Field methods for determining constants of tacheometer. 4. Limitations of Tacheometry	**15 L**
Unit 4	**Curve Setting** 1. Types of curves used in roads and railway alignments. 2. Notations of simple circular curve designation of the curve	**10 L**
Unit 5	**Advanced Surveying Equipment's** 1. Principles of Electronic Distance Meter (EDM), its components parts and their Functions, Use of EDM 2. Construction and use of one second Micro Optic Theodolite, Electronic Digital Theodolite, Features of electronic theodolites. 3. Construction and use of Total Station, Temporary adjustments, Use of Function keys	**10 L**

Suggested readings:

1. V. K. Kumawat, Advanced Surveying, Tech-Max Publication, Pune, Innovative polytechnical Division, 2018-2019.
2. Kanetkar, T.P. and Kulkerni, S.V. , Surveying and leveling, Pune Vidyarthi Gruh Prakashan, Pune, ISBN No.:13:9788185825007
3. N.N. Basak, Surveying and Leveling, McGraw Hill Education Pvt. Ltd. Noida. ISBN No.93-3290153-8
4. B.C. Punmia, Ashokkumar Jain, Arun Kumar, Surveying Vol. I and Surveying Vol. II, Laxmi Publication Pvt. Ltd, New Dehli. ISBN No. 13:9788170088837

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C402(B).1	Students will be able to summarize basic concepts of Surveying in Geosciences.	5
C402(B).2	Students will be able to operate advanced equipment's used in surveying and Levelling which is important part of Geosciences.	3
C402(B).3	Students will be able to use this knowledge in plan their career in Field of Surveys and Engineering Geology.	4

CORE COURSE		
GS-403: ENGINEERING AND ENVIRONMENTAL GEOSCIENCES		
	Course Objectives: 1. To learn the Rock mechanics, Engineering properties of rocks and soil 2. To learn different types of geological hazards. 3. To study the role of geology in construction of major civil engineering projects 4. To learn applicability of geomorphology in the field of mineral prospecting, engineering geology, watershed management, urban planning and environmental studies. 5. To develop the skill for calculation of Environmental Impact Assessment.	
Unit 1	**Introduction to Engineering Geology** 1. Scope of Engineering Geology 2. Engineering properties of rocks and soils and their determination 3. Rock mechanics: Behavior of rocks under stress, Rock failure mechanisms	**10 L**
Unit 2	**Construction Sites** 1. Geological considerations for the selection of dam sites 2. Geological considerations for spillways 3. Geological considerations for tunnels and bridges	**15 L**
Unit 3	**Geo-material** 1. Building stones and road metals; Aggregates and its classification 2. Rock testing: Mechanical test, Chemical test, Durability test 3. Aggregate resource development: a) Requirement of primary fragmentation b) Planning of quarry, hill slope side or open pit c) Removal of overburden and its disposition at suitable site d) Selection of drilling, blasting method for main blasting and secondary breaking for given size of fragmentation. e) Selection of equipment's for drilling, loading, hauling to crusher site f) Methods of extraction of aggregate resources g) Use of synthetic materials used as remedial measures. h) Estimation of overburden thickness and rock strata classification	**15 L**

Unit 4	**Introduction to Environmental Geology** 1. Introduction, fundamental concepts, scope, Man and environment. 2. Natural and Man- made hazards and disasters. a) Lithospheric hazards-volcanoes, earthquakes, landslides, land subsidence, tsunamis, meteorite strike, etc. b) Hydrospheric hazards- sea level changes, coastal hazards, water pollution (sea, river, and ground water), floods c) Atmospheric hazards- air pollution, acid rain, etc. d) Man-made hazards- industrial, nuclear, mining, etc. 3. Remedial measures: Introduction, origin, characteristics, and preventive measures- water pollution, soil pollution and air pollution 4. EIA (Environmental Impact Assessment) and case studies	**10 L**
Unit 5	**Marine Geology** 1. Introduction and significance of Physical, Chemical and Biological oceanography 2. Shallow and deep-water Marine Resources and significance: Polymetallic nodules, oozes etc. 3. Tidal Energy: Introduction and harnessing 4. Marine pollution: Oil spills and nuclear waste disposal	**10 L**

Suggested readings:

1. Bell, F.G. (1999) Geological Hazards, Routledge, London.
2. Bryant, E. (1985) Natural Hazards, Cambridge Univ. Press.
3. Keller, E.A. (1978) Environmental Geology, Bell and Howell, USA.
4. Lal, D.S. (2007) Climatology, Sharda Pustak Bhawan, Allahabad.
5. Perry, C.T. and Taylor, K.G. (2006) Environmental Sedimentology, Blackwell Publ.
6. Patwardhan, A.M. (1999) The Dynamic Earth System, Prentice Hall.
7. Smith, K. (1992) Environmental Hazards, Routledge, London.
8. Subramaniam, V. (2001) Textbook in Environmental Science, Narosa International.
9. Valdiya, K.S. (1987) Environmental Geology – Indian Context, Tata McGraw Hill.
10. Bell, F.G. (1981) Engineering properties of Soils and Rocks, Butterworths Publication, London.
11. Bell, F.G. (1993) Fundamentals of Engineering geology, Butterworths Publication, London.
12. Garg, S.K. (2009) Physical and Engineering Geology, (6th Ed.), Khanna Publishers, New Delhi.
13. GSI (1975) Engineering Geology Case Histories, Geological Survey of India, Misc. Publ., No. 29.
14. Gupte, R.B. (2002) Textbook of Engineering Geology. Vidyarthi Griha Prakashan, Pune.
15. Keary, P., Brooks, M. and Hill, I. (2002) An introduction to geophysical exploration, (3rd Ed.), Blackwell.
16. Kesavulu, N.C. (2009) Textbook of engineering geology, (2nd Ed.), Macmillan Publishers India ltd.
17. Krynine, D.P. and Judd, W.R. (1998) Principles of Engineering Geology and Geotechnics. CBS Publishers & Distributors, New Delhi.
18. Reddy, D.V. (1998) Engineering Geology for Civil Engineering. Oxford & IBH Pub.Co. Pvt. Ltd., Delhi.
19. Rider, M.H. (1986) The Geological Interpretation of Well Logs. (Rev. Ed.) Whittles Publishing, Caithness.
20. Ries, H. and Watson, T.L. (1947) Elements of Engineering Geology (2nd Ed.). John Wiley & Sons, New York.
21. Schultz, J.R. and Cleaves, A.B. (1951) Geology in Engineering. John Willey and Sons, New York.
22. Singh, P. (1994) Engineering and General Geology. S.K. Kataria and Sons, Delhi.
23. Telford, W.M., Geldart, L.P., Sherrif, R.E. and Keys, D.A. (1976) Applied Geophysics,

Cambridge Univ. Press.
24. Verma, B.P. (1997). Rock Mechanics for Engineers (3rd Ed.), Khanna Publishers, New Delhi.

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C403.1	Students will be able to interpret engineering geological data.	2
C403.2	Students will be able to calculate EIA parameters and prepare EIA reports.	3
C403.3	Students will be able to plan their carrier in field of Engineering geology, Geo-material and Environmental Geosciences.	4

CORE COURSE	
GS-404: PRACTICALS RELATED TO PETROLEUM GEOSCIENCES AND HYDROGEOLOGY	
	Course Objectives: 1. To provide hands on practice regarding preparation of structure contour maps and structural cross sections. 2. To learn the geologic and bio-stratigraphic well-log correlations. 3. To plot and analysis of hydro geochemical data. 4. To develop a skill of interpretation of borehole data, lithologs and preparation of hazard zonation maps.
1	Lithofacies analysis
2	Preparation of structure contour maps and structural cross sections
3	Porosity and permeability measurements
4	Well correlations: geologic and bio-stratigraphic
5	Well log interpretations
6	Isopach and lithofacies maps, Fence diagram
7	Oil Reserve Estimation
8	Core analysis
9	Analysis of rainfall data
10	Preparation of water level contour maps and their interpretation
11	Analysis of pumping test data using different methods of aquifer and well characteristics determination
12	Plotting and analysis of hydrogeochemical data
13	Morphometric analysis and site selection for water conservative measures
14	Water audit
15	Various methods of Surveying used in engineering geology, Chain Surveys, Plane table surveys, Use of Surveying equipment's

16	Determination of Engineering properties of Geological materials
17	Interpretation of borehole data, Preparation of bore logs / Lithologs
18	Preparation of Report and Presentation of Engineering data
19	Water and Soil analysis, Plotting and interpretation of geochemical data.
20	Preparation of hazard Zonation map
21	Quantification of EIA
22	Heavy Mineral: Separation, identification, and interpretation
23	Sediment Size and shape Analysis and interpretation
24	Trace element Analysis
25	Organic Carbon and Total Phosphorus Analysis
26	Foraminiferal and Nano-plankton's studies

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C404.1	Students will be able to prepare water level contour maps, analysis of rainfall data analysis.	**3**
C404.2	Students will be able to interpret well logs and they may be able to prepare hazard zonation maps.	**3**
C404.3	Students will be able to plan their career in the field of Hydrogeology and petroleum sector.	**4**

CORE COURSE	
GS-405: DISSERTATION/ INTERNSHIP	
	Course Objectives: 1. To prepare students for carrying out independent research on a topic of their choice within the field of geology 2. To develop students for preparation of report and for presentation of geological problem in the form of a dissertation. 3. To demonstrate skills and knowledge acquired throughout the taught component of the M. Sc. programme. 4. To provide platform for working in National Level Institutes.
	Topic of the Dissertation work will be allotted to students as per the specialization of the teacher and interest of the students.

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
C405.1	Dissertation can help students to develop skill of data collection, data analysis and to check its applicability for the development of subject and the society.	**3**
C405.2	Students may get exposed to different geological problems and they may have challenges to provide solution for those problems.	**5**

C405.3	Students may take the review of the key research questions within the field of geology on which they will carry out independent research.	**2**

M.Sc. Part II Semester IV (Applied Geology): Audit Courses

	AC-401(A): Human Rights **(Professional and Social + Value Added Audit course; Practical; 2 Credits)** **(Optional: Campus-level)**	
	Course Objectives (CObs): • To make students aware about human rights and human values.	
Unit 1	**Introduction to Human Rights** 1.1 Concept of Human Rights 1.2 Nature and Scope of Human Rights 1.3 Fundamental Rights and Fundamental Duties 1.4 Interrelation of Rights and Duties	**6 hrs.**
Unit 2	**Human Rights in India** 2.1 Meaning and Significance of **:** 1) Right to Equality 2) Right to Freedom, 3) Right against Exploitation, 4) Right to Freedom of Religion, 5) Cultural and Educational Rights, and 6) Right to Constitutional Remedies. 2.2 Constitutional Provisions for Human Rights 2.3 Declaration of Human Rights 2.4: National Human Rights Commission	**8 hrs.**
Unit 3	**Human Values** 3.1: Meaning and Definitions of Values 3.2: Importance of values in the life of Individual 3.3: Types of Values 3.4: Programmes for conservation of Values	**8 hrs.**
Unit 4	**Status of Social and Economically Disadvantaged people and their rights** : Rights of women and children in the context of Social status : The Minorities and Human Rights : Status of SC/ST and other Indigenous People in the Indian Scenario 4.4: Human rights of economically disadvantaged Society	**8 hrs.**
Suggested readings: 1. Human rights education – YCMOU, Nasik 2. Value education – SCERT, Pune 3. Human rights reference handbook – Lucille whare		

Course Outcomes (COts):

On completion of this course, the student will be able to:

COt No.	Course Outcomes	Cognitive level
AC401A.1	Practice the learned issues under human rights and human values in real life.	**3**
AC401A.2	Provide social justices to people around them and provide guidance about human rights to their friends, parents and relatives.	**5**

	AC-401(B): Current Affairs **(Professional and Social + Value Added Audit course; Practical; 2 Credits)** **(Optional: Campus-level)**		
	Course Objectives (CObs): • To make students updated about current affairs of India and world.		
	Title	**Content**	**Hours**
Unit 1	litics & Economy	• National & International Political Activity, Organization. • Economy & Business, Corporate world	08
Unit 2	Awards and recognitions	• National & International Awards and recognitions • Books and authors	07
Unit 3	ence & Technology	• Software, Automobile, Space Research • New inventions and discoveries	07
Unit 4	Environment & Sports	• Summit & conference, Ecology & Climate, Organization. • National & International Games, Olympics, commonwealth etc.	08

Suggested readings (Use recent years' data and current literature):

1. India 2019, by Publications Division Government of India
2. Manorama Year Book by Philip Mathew,
3. India 2019, Rajiv Maharshi
4. Quick General Knowledge 2018 with Current Affairs Update, Disha Experts
5. General Knowledge 2018: Latest Who's Who & Current Affairs by RPH Editorial Board.

Course Outcomes (COts):

On completion of this course, the student will be able to:

COt No.	Course Outcomes	Cognitive level
AC401B.1	Identify important issues currently/ recently happening in India or world.	**5**
AC401B.2	Summarize current affairs regularly.	**6**

	AC-401(C): MEDICAL GEOLOGY **(Professional and Social + Value Added Audit course; Practical; 2 Credits)** **(Optional: Campus-level)**
	Course Objectives (CObs): 1. To make students updated for carrying out investigations of quality of natural resources in purview of health.
	CONTENT OF THE SYLLABUS
1.	Present and future prospective: geological factors of environmental health
2.	Trace elements and human health, chronic diseases, and geologic environment.
3.	Trace elements associated vector and carcinogenic diseases.
4.	Exposure of human (active/passive) to trace metal borne health hazard (occupational and dietary).
5.	Water borne diseases-cause and remedies. Ores and rock processing industries and their impact on human health.
6.	**ASSIGNMENT:** Assignment to students for carrying out investigations of quality of natural resources in purview of health.

Course Outcomes:

On completion of this course, it is expected that:

COt No.	Course Outcomes	Cognitive level
AC401C.1	Students will be able to identify minerals helpful to human health.	**2**
AC401C.2	Student will learn how water and soil quality affecting human	**6**

	health?	

AC-401(D): WATERSHED MANAGEMENT **(Professional and Social + Value Added Audit course; Practical; 2 Credits)** **(Optional: Campus-level)**	
Course Objectives (CObs): 1. To make students aware about the concept of watershed management.	
	CONTENT OF THE SYLLABUS
1.	Fundamental of Watershed Management
2.	Elements of Hydrology
3.	Soil and Water Conservation
4.	Rainfed Farming
5.	Funding, Monitoring, Evaluation and Capacity Building
6.	Project Formulation
7.	**ASSIGNMENT:** Seminar and Review articles for promoting and spreading awareness about watershed management.

Course Outcomes:

On completion of this course, the student will be able to:

COt No.	Course Outcomes	Cognitive level
AC401D.1	Practice learned on field affecting watershed management.	**3**
AC401D.2	Provide awareness about importance of watershed management to local community	**2**

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