BANGALORE UNIVERSITY

Department of Geology

Jnanabharathi, Bangalore -560 056

Proposed Regulation and Syllabus for Four-Years Under Graduate (UG) Programmes in Geology as Per National Education Policy (NEP-2020)

I & II Semester B.Sc., (Basic & Hons) Geology
Choice Based Credit System (CBCS)
(Semester Scheme)
(Effective from the Academic Year 2021-22)

Department of Geology
Bangalore University,Bangalore

Proceedings of the Meeting of Board of studies in Earth Science (UG) syllabus as per NEP (2021-22) held on 20-09-2021 at the Chairman chamber, Department of Geology.

Members Present:

1. Prof. M.R. Janardhana	University of Mysore	External Member
2. Prof. N. Malarkodi	Bangalore University	Member
3. Prof. H. C. Vajrappa	Bangalore University	Member
4. Prof. A. K. Jeelani	Nrupathunga University	Co. Op. Member
5. Prof. P. C. Nagesh	Bangalore University	Chairman, B.O.S.

Members not present:

1. Prof. M. E. Patil	Kuvempu University	Member

The agenda was discussed and the resolutions passed are as follows:

The Board approved the I and II syllabus for B.Sc.,(Basic/Hons.) as per NEP after detailed discussion and certain modifications.

		Signature
Prof. M. R. Janardhana	University of Mysore	20/09/2021
Prof. N. Malarkodi	Bangalore University	
Prof. H. C. Vajrappa	Bangalore University	20/9/21
Prof. A. K. Jeelani	Nrupathunga University	20/9/21

Prof. P. C. Nagesh

CHAIRMAN, B.O.S.

Preamble

The objective of any programme at Higher Education Institute is to prepare their students for the society at large. The Bangalore University envisions all its programmes in the best interest of their students and in this endeavour it offers a new vision to all its Under-Graduate courses. It imbibes a Learning Outcome-based Curriculum Framework (LOCF) for all its Under Graduate programmes. The LOCF approach is envisioned to provide a focused, outcome-based syllabus at the undergraduate level with an agenda to structure the teaching-learning experiences in a more student centric manner. The LOCF approach has been adopted to strengthen students' experiences as they engage themselves in the programme of their choice. The Under-Graduate Programmes will prepare the students for both, academia and employability. Each programme vividly elaborates its nature and promises the outcomes that are to be accomplished by studying the courses. The programmes also state the attributes that it offers to inculcate at the graduation level. The graduate attributes encompass values related to well-being, emotional stability, critical thinking, social justice and also skills for employability. In short, each programme prepares students for sustainability and life-long learning.

The new curriculum of B.Sc.(Hons) Geology offers through innovative classroom teaching with ICT tools, models and demonstrations, a conceptual background to the geological processes which generally operate at time scales ranging from days to billions of years and their products. Intensive field training exposes the students to the geological processes that operate in nature and their relevance to natural resource exploration, understanding natural hazards and environmental changes. The programme addresses current environmental issues of societal relevance, such as climate change providing a deep time understanding of climate change in the geological past. Sustainable development of natural resources keeping a balance between economics and environment is what a geology graduate student is expected to learn. The programme also provides a basic understanding of geo-heritage sites and their protection and preservation for posterity. As a whole, the students are expected to understand the nature of lithosphere, hydrosphere, atmosphere, and biosphere interactions and their final products from a deep time perspective. The Bangalore University hopes the LOCF approach of the programme B.Sc. (Hons) Geology will help students in making an informed decision regarding the goals that they wish to pursue in further education and life, at large.

Courses in Geology cover core components on minerals, rocks, fossils, fossil fuels, groundwater nuclear energy resources, geological hazards, etc., Needless to emphasize minerals are fundamental raw materials that all industries depend upon, and fuels like coal petroleum, and natural gas, and

radioactive resources are the driving force of the modern economy. Sound knowledge of Geology, thus critically important for earth resources exploration and exploitation which are vital for our industries run both for public and private. Another emerging domain of concern is mitigating natural disasters caused by hazards like climate change, global warming, earthquakes, tsunamis, volcanoes, and landslides, etc., which necessitates systematic study and understanding of the earth process and their relation to the atmospheric process. The graduate course framed here encompasses different facets of Geology which is aimed at preparing graduate students with sound knowledge who could contribute to academic institutions or any organizations including research organizations with a novel objective of better earth resources management and nation-building.

Graduate attributes in Geology

The new curriculum of B.Sc.(Hons) Geology is framed under National Education Policy (NEP 2020) is toprepare their students for society at large. Each program vividly elaborates its nature and promises the outcomes that are to be accomplished by studying the courses. The Geology programs also state the attributes that it offers to inculcate at the graduation level. The graduate attributes encompass values related to well-being, emotional stability, critical thinking, social justice, and also skills for employability. Being a fast economically developing country with an increasing population, the nation is faced with innumerable problems related to depleting natural resources, acute shortage of energy, natural disasters, and many types of environmental hazards. Two-third of the Indian subcontinent lies in the seismic zones of moderate to severe intensity. Solution and management of many of these problems can be met by understanding the earth more intensively and extensively, which could be achieved by pursuing a course inGeology. It is an exciting course and has both fundamental as well as applied utility.

The course aims

- To help students build up a progressive and successful career in Geology.
- To enrich students' knowledge and train them in the pure and applied geological sciences.
- To Provide an updated education.
- To impart more field-oriented knowledge.
- To inculcate the sense of scientific responsibilities and social and environment awareness.
- To inculcation of values and knowledge
- To make them well-being responsible citizen

- To encourage critical thinking with skills of employability.
- To introduce the concepts of application and research in Geology
- Create a sense of preservation and conservation of natural resources.
- To prepares students for sustainability and life-long learning
- To inculcation of values and knowledge within students that will make them well-being responsible citizen and encourage in critical thinking with skills of employability.

In short, each program prepares students for sustainability and lifelong learning.

Flexibility

- The programmes are flexible enough to allow liberty to students in designing them according to their requirements. Students may choose a single Major, one Major with a Minor, and one Major with two Minors. Teacher Education or Vocational courses may be chosen in place of Minor/s. Below listed are the various options students may choose from.
- One Major subject/discipline, Two Languages, Generic Electives, Ability Enhancement, Skill Development, and Vocational courses including Extracurricular Activities.
- One Major and one Minor subject/discipline along with Languages, Generic Electives, Ability Enhancement, Skill Development and Vocational courses including Extracurricular Activities
- Two Major subject/disciplines along with Languages, Generic Electives, Ability Enhancement, Skill Development and Vocational courses, including Extracurricular Activities (subject to fulfilling the requirements as stated in 3. i and 3. ii)
- One Major subject/discipline and one Vocational course along with Languages, Generic Electives, Ability Enhancement, and Skill Development and courses including Extracurricular Activities.
- One Major Discipline and One Education Discipline along with Languages, Generic Electives, Ability Enhancement, and Skill Development Courses including Extracurricular Activities.

REGULATIONS

GENERAL INSTRUCTIONS/ GUIDELINES FOR EXECUTION OF CURRICULUM AND EXAMINATION

DURATION OF THE COURSE: Ten Semesters

I. The B.Sc. Degree Geology Programme will be of **Three Years** duration semester-based Choice Based Credit System [CBCS] course.
II. The B.Sc. (Hons) Geology Programme will be of **Four Years** duration semester-based Choice Based Credit System [CBCS] courses.
III. There will be **One Year** M.Sc., Geology Degree Programmesemester-based Choice Based Credit System [CBCS] course.

ELIGIBILITY FOR ADMISSION

Subject prerequisites: To study this subject, a student must have had the subject(s) …**Physics/Mathematics/ Chemistry/ Biological Sciences** …. in class/12th. or Completed two years Pre-University Science course of Karnataka State or equivalent thereto and provided they have secured at least 50% marks in the aggregate of all papers studied at the qualifying examination are eligible for admission in to this course.

In the case of SC/ST/Category-I Candidates, the minimum percentage of marks required shall be in aggregate less by 5% i.e., 45% in the qualifying examination.

Medium of instruction

The medium of instruction shall be English.

Attendance

- A student shall be considered to have satisfied the requirement of attendance for the semester, if he/she has attended not less than 75% in aggregate of the number of working periods in each of the subjects.
- A student who fails to secure 75% attendance in a course shall not be permitted to take the University examinations and shall be required to repeat that semester.

Pedagogy

- It will be a blend of Lectures, Seminars, Case studies, visits, Guest Lectures designed by the course teachers. The whole exercise will be a participative learning process.

- There will be of 35 to 30 contact hours per week. This will include practicals and visit to institutions/organisation

Programme outcomes: Three Academic Years Bachelor of Science, four years Bachelor of Science (Hons) Degree and one-year Master of Science in Geology programme is designed to educate students for success as a geoscientist having employability in the government sector, public sector, private sector, research institutes, or further qualifying other national examinations to pursue further study.

Course outcomes: First and Second Semester
After completing the course, the student will be able to

- learn the origin of the solar system and Earth
- understand the internal structure of Earth
- understand the role of weathering agents
- learn the fundamentals of geological mapping.
- learn how to read geologic maps and solve simple map problems using strikes and preparations of cross-sections.
- learn the Concept of plate tectonics
- learn earthquakes and Volcanoes
- interpret the geological maps
- measure the geological data from the field
- learn the mineral and their types
- understand the crystal formation, form, and occurrence
- learn the formation of mineral groups and resource
- see and feel the natural mineral
- learn to identify the mineral in hand specimens
- learn the rock formation including minerals genesis
- have skills to work in quarrying, mining, rock polishing, cement, silica/glass, sand mining, brick, ceramic, pottery, and refractory industries.
- exposed to start their entrepreneurship.
- benefited work/carry research in the interdisciplinary science to get original ideas and look for new reserves
- understand fossils which help to unravel the mystery of the life in the past
- understand the evolution of life on earth.
- indicate the rich mineral deposits like petroleum, coal, and other minerals.

Programme specific outcomes: Geological excursion (Fieldwork) would be an important component of the B.Sc., & B.Sc. (Hons) Programme in Geology for laying a robust foundation for the budding geologists. Students will get exposure

to actual rocks during Geological excursions (Fieldwork). Students will learn the data collection, measurements, and interpretations.

Job Profiles and Potential Recruiters for employing the graduates of Geology

Job Profiles

The students graduating from the department of Geology will be invaluable to the industry due to interdisciplinary and quantitative nature of the program. The students are expected to be recruited by the energy industry, construction industry, industries involved in mineral exploration, environmental industries and space industries, including satellite tracking and meteorology. Students will also have career opportunity in Public Sector Unit (PSU) like Geological Survey, Coal India, ONGC and Mineral Exploration Corporation Ltd. Students of the B.Sc., &M.Sc., programme in Earth Sciences will also have excellent opportunities to opt for academic and research careers. The undergraduate program in Earth Sciences will also prepare students for higher studies in post graduate programs within and outside India. Being a course that involves several subjects, finding a job that is tailored to the interests is not hard. A graduate of Geology can branch out into many fields and thus has innumerable job opportunities available. Listed below are some of the most coveted jobs in the field –

List of Potential Recruiters for employing the graduates of Geology

There is a need for Earth Sciences graduates in almost every field today. With the rapid depletion of fossil fuels, such graduates with immense knowledge on the Earth are in high demand. Listed below are some of the highest paying recruiters for graduates of Geology.

1	Geological Survey of India	16	Private & Public Sector Mines operated for Industrial Raw Materials like
2	Oil and Natural Gas Corporation & Oil India Ltd	17	Rock Phosphate, Lime stone, Dolomite, Magnesite, Gypsum, Beach Sand
3	Central & State Governments Ground Water Boards or Agencies	18	Minerals (Garnet, Rutile & Ilmenite), Barytes, Bauxite, Bentonite, Graphite,
4	National Mineral Development Corporation	19	Talc, Fireclay, Kaolin, Vermiculite, Wollastonte& Mica etc.

5	Atomic Minerals Division, BARC, Uranium Corporation	20	Private & Public Sectors Mines / Quarries operated for Building / Decorative
6	Indian Bureau of Mines	21	dimensional stones (Granites, Marbles, Slates, Sand stone etc.)
7	Indian Space Research Organization	22	Diamond & Precious- Gem Stones
8	Mines and Geology Directorates of the State Governments	23	Ferro-alloy producers
9	Coal & Lignite Producers	24	Reliance Petroleum
10	Mineral Exploration Corporation Ltd	25	Indian Space Research Organization
11	Private and Public Sector Steel Plants	26	Environmental Consulting Firms
12	National Aluminium Company	27	Engineering Firms
13	State Government Mining Companies like Odisha Mining Co	28	Academic Institutions
14	Mysore Minerals Ltd. etc	29	Research Centres
15	Private & Public Sector Mines operated for Ferrous & Non - Ferrous Metals	30	Private companies dealing with GIS and Remote Sensing

EXAMINATION

Note on Continuous Evaluation

1. The breakup of the continuous evaluation marks are as follows:

Theory tests	25
Assignment	10
Attendance	05
Total	**40 marks**

2. **Practicals**

Practical Test/Record	25 +10=35
Viva-voce	10
Active participation in practical classes	05
Total	**50 marks**

The format of giving marks for attendance is the same as for the theory papers.

At the end of the semester, the continuous evaluation marks are put up on the Notice Board and students are asked to verify the marks and bring any

COURSE PATTERN AND SCHEME OF EXAMINATION for B.Sc. / B.Sc. (Hons.)
as per NEP (2021-22 and onwards)

SUBJECT: GEOLOGY

Sl. No.	Semester	Title of the Paper	Teaching Hours	Hours /week		Examination Pattern Max. & Min. Marks /Paper						Duration of Exam (hours)		Total Marks / paper	Credits	
						Theory			Practical							
				Theory	Practical	Max.	Min.	IA	Max.	Min.	IA	Theory	Practical		Theory	Practical
1	I	**GEO-A1**: Earth System Science Fundamentals **GEO-P1** Practical: Maps, Sediment, Soil & Field Visit	**56** **30**	**4**	**4**	**60**	**21**	**40**	**50**	**18**	**50**	**3**	**4**	**200**	**4**	**2**
		GEO-OE-1 1.1 Crystallography, Mineralogy and Economic Minerals 1.2 Basics of Earth System Science 1.3 Geohazads and Mitigation Strategies	**48**	**3**	**-**	**60**	**21**	**40**	**-**	**-**	**-**	**3**	**-**	**100**	**3**	**-**
2	II	**GEO A2** Basic of Crystallography Mineralogy and Petrology **GEO P2** **Practical:**Crystallography Mineralogy and Petrology	**56** **30**	**4**	**4**	**60**	**21**	**40**	**50**	**18**	**50**	**3**	**4**	**200**	**4**	**2**
		GEO OE-2 2.1 Industrial Minerals 2.2 Paleobiology 2.3 Medical Geology	**48**	**3**	**-**	**60**	**21**	**40**	**-**	**-**	**-**	**3**	**-**	**100**	**3**	**-**

Scheme of Internal Assessment Marks:Theory

Sl.No.	Particular	IA Marks
1	Attendance	**05**
2	Internal Tests (Minimum of Two)	**25**
3	Assignments /Seminar / Case Study / Project work / Reports on - visits to industries/ exhibitions / science centres / active participation in the Field work, etc.	**10**
	TOTAL Theory IA Marks	**40**

Practicals:

Sl. No.	Particular	IA Marks
1	Practical Test/ Record	**25+10=35**
2	Viva –Voce	**10**
3	Active participation in practical classes	**05**
	TOTAL Practical IA Marks	**50**

discrepancies to the notice of the chairperson. The Internal Marks Register can also be checked by the students to ensure that the marks entered are correct.

Internal Assessment

Marks for internal assessment shall be awarded on the basis of Attendance, Test, Case Studies and Assignments / Seminars and other co-curricular activities. The internal assessment marks shall be notified on the department / college notice board for the information of the students and it shall be communicated to the Registrar (Evaluation) within 10 days before the commencement of the University examinations, and the Registrar (Evaluation) shall have access to the records of such internal assessment evaluations.

Assessment
Weightage for Assessments (in Percentage)

Type of Course	Formative Assessment IA	Summative Assessment
Theory	40	60
Practical	50	50
Project	40	60
Experimental Learning (Interships, etc.,)	40	60

1. The prescribed courses of core paper 4 credits and open elective of 3 credits shall be evaluated for 100 marks and that of less than 2 credits, including practical, shall be evaluated for 100 marks. The project work/dissertation shall have 6 credits and be evaluated for 100 marks.
2. There shall be a continuous assessment of the student.
    i. Internal assessment - 40 marks allotted for theory papers of each Course; and 50 marks for practicals
    ii. Semester-end written examination conducted by University -60 marks for theory 40 practical.

a. Continuous tests: One hour every week, is put aside in the timetable as a „test period". These tests start after completion of the first month of course work. These tests go in a sequential order, such that in the first week, the students have a test in paper I, the second week in paper II, in the third week in paper III and in the fourth week in paper IV and V. The cycle keeps repeating such that every student appears for three tests in every theory paper. All tests

are compulsory. Since it is in the timetable and the students know the schedule of tests before hand, they are prepared for the tests. If the „test day" happens to be a holiday, the test is shifted to another period in the week itself, based on the convenience of the students and the teacher concerned. The test is generally for 25 marks and consists of short notes. These test marks are entered in the register kept in the office by the teacher concerned. For the purpose of continuous evaluation, the total of the three tests are calculated and then converted taking into account that the maximum for continuous tests is only 25 marks. Previously, three tests were given and the best two were taken for calculation. This was to ensure that students who had missed one test for genuine reasons test if they had done the first two tests well, thus defeating the very purpose of continuous evaluation.

However, whether the best two or all three should be taken into consideration for calculation can be decided at the level of the departmental council. If need be, one "repeat test" can be given at the end of the semester to all those students who have missed any one test, so that the average of three tests can still be calculated. This can be held at the convenience of the department.

b.Assignment

Every student submits an assignment/makes a presentation to the class/conducts a seminar etc for every paper. The list of topics is given at the beginning of the semester and students choose their topic. This is evaluated by the subject teacher for 10 marks and these marks are entered in the Internal Marks Register.

c. Attendance

Minimum percentage of attendance to be able to write the exam is 75%. Marks for attendance are as follows:

95 – 100% 05
90 – 94% 04
85 – 89% 03
80 – 84% 02
75 – 80% 01

Every month, the percentage of attendance for each student is read out in class, so that students who are on the borderline can make up.

d. Board of Examiners (BOE):

Board of examiners constituted by the University shall consist of a Chairman, internal and external members. The external members from other universities.

The board shall scrutinize the question papers and shall forward for the approval of university.

e. Results:

A candidate should obtain a minimum of 40% marks in each of the papers in the University examination and 50% marks including internal assessment marks. A candidate should obtain a minimum of 50% marks in all Semesters). The candidates who have passed in all the semester examinations are eligible for the award of the Four-Years B.Sc. (Basic & Hons) Degree Program in Geology.

e. Carry Over:

A candidate who fails in a lower semester examination may go to the higher semester, however, the result of the candidates who have passed the VI semester examination but not passed the lower semester examinations shall be declared as NCL (not completed lower semester examinations). Such candidates shall be eligible for the degree only after completion of all the lower semester examinations.

f. Question Paper Pattern:

- The theory exam will be conducting for 60 Marks and question paper will consist of four sections namely Short, Medium and Long answer questions.
- Section A (compulsory, covering syllabus from all the units), Each question carries 2 marks and student has to answer 10 questions. (20)
- Section B (Unit I & II), Each question carries 5 marks and student has to answer 4 questions. (20).
- section C (Unit III &IV) Each question carries 10 marks and student has to answer 2 questions. (20)
- The duration of the examination will be 3 hours.

DETAILS OF PAPERS FOR FOUR YEARS B.Sc. (Hons.)IN GEOLOGY

- Total Discipline Core(DSC) = 14 Papers
- Total Discipline Specific Elective (DSE) = 3 DSE consists of 11 Papers (Two elective papers will be offered in the 7th Semester and 6 vocational papers in the 5th & 6th semester; the student has an option of choosing one elective and one vocational paper).
- ERS DSC E-1-2 will be offered in the 7th semester and RESEARCH METHODOLOGY paper and Internship
- ERS DSE-3 will be offered in the 8th semester and RESEARCH PROJECT
- Open Elective (OE) = 16 papers (Each student has to select 1 Open Elective each in 1st, 2nd, 3rd & 4th Semester. At each semester there are (4) options provided. The student can select anyone).

- Ability Enhancement Compulsory Course (AECC) = 6 Papers (Languages) + 2 Papers (Environmental Studies and Constitution) = 10 Papers
- Skill Enhancement Course (SEC) = 4 (Skill Based) + 8 (Value based) = 12 Papers

Discipline Specific Core Course (DSC) for B.Sc. (Honours) Geology

All the courses have 6 credits with 4 credits of theory and 2 credits of practicals.

Year	Sem	Course Code	Paper Title	Theory/ Practical	Credits
1	I	GEO-A1 GEO-P1	Earth System Science Fundamentals Practical: Maps, Sediment, Soil & Field Visit	Theory Practical	4 2
	II	GEOA2 GEOP2	Basic of Crystallography, Mineralogy and Petrology Practical: Crystallography, Mineralogy and Petrology	Theory Practical	4 2
2	III	GEOA3 GEOP3	Principles of Stratigraphy, Paleontology& Geology of India Practical: Stratigtaphy&Paleontology	Theory Practical	4 2
	IV	GEOA4 GEOP4	Structural Geology & Hydrogeology Practical: Water Analysis, Surveying and Thin Section Making	Theory Practical	4 2
3	V	GEOA5 GEOP5 GEOA6 GEO A6	Environmental Science and Geotectonics Practical: Structural Geology & Field visit Geochemistry and Mining Geology Practical: Ore Geology	Theory Practical Theory Practical	3 2 3 2
	VI	GEOA7 GEOP7 GEOA8 GEOP8	Applied Geophysics Practical: Applied Geophysics Mineral Processing including Marine Mineral Resources Practical: Economic Geology	Theory Practical Theory Practical	3 2 3 2
4	VII	GEOA9 GEOP 9 GEOA10	Advanced Earth Systems Practical: GIS and Field Visit Oceangraphy and Atmospheric Sciences	Theory Practical Theory	3 2 3

		GEOP10	Practical Image Analysis &Geostatistics	Practical	2
		GEOA11	Advanced Petrology	Theory	2
		GEOP11	Practical: Thin section Petrology and Petrochemistry	Practical	2
	VIII	GEOA12	Advanced Paleontology	Theory	2
		GEOP12	Practical: Advanced Paleontology	Practical	2
		GEOA13	Analytical Techniques in Earth	Theory	2
		GEOP13	Science	Practical	2
		GEOA14	Practical: X-ray, FTIR, Spectroscopic Techniques	Theory	3
			Evaluation and Management of Mineral Deposits OR Nanogeoscience		

Discipline Specific Electives (DSE/OE) for B.Sc. (Honours) Geology

Year	Sem	Course Code	Paper Title	Theory/ Practical	Credits
1	I	GEO-OE-1	1.1 Crystallography, Mineralogy and Economic Minerals 1.2 Basics of Earth System Science 1.3 Geohazards and Mitigation Strategies	Theory	3
	II	GEOOE-2	2.1 Industrial Minerals 2.2 Paleobiology 2.3 Medical Geology	Theory	3
2	III	GEOOE-3	3.1 Watershed Management 3.2 Marine Geology 3.3 Climatology	Theory	3
	IV	GEOOE-4	4.1 Geotourism 4.2 Geophysical Exploration 4.3 Geology and Society	Theory	3
3	V	GEO**Vocational -1**	V-1.2 Remote Sensing and GIS V.1.2 Geostatistics and V.1.3 Computer Applications in Earth Science	Theory	3

	VI	GEO **Vocational -2**	V.2.1 Mineral Exploration & Mining V.2.2 Medical Geology V.2.3 Thin section making and Geological Mapping Intership (In companies, Mines & Remote Sensing Agencies)	Theory	3 2
4	VII	GEODSE-1 DSE-2	i. Experimental Petrology ii. Remote Sensing and Image\Processing iii. Gemology iv. Global Change Studies v. Enterpreneurship in Geoscience vi. Medical Geology Research. Methodology	Theory	3 3 3
	VIII	GEODSE-3	i. Plate tectonics ii. Petroleum Geology iii. Critical and Strategic Minerals of Karnataka iv. Mineral Marketing v. Hyperspectral Remote Sensing and Mineral Targeting Research Project in Earth Science	Field work Research Project work	3 6

Contents

EXIT OPTIONS AND CREDIT REQUIREMENTS	
Progressive Certificate in Science, Diploma in Science, Bachelor of Science Degree or Bachelor of Science Degree with Honours in Geology is awarded at the completion of every progressive year.	
Exit Options	**Credit requirements**
CERTIFICATE IN SCIENCE at the successful completion of First year (Two Semesters) of the Four Years Multidisciplinary Undergraduate Degree Programme.	50 credits
DIPLOMA IN SCIENCE at the successful completion of Second year (Four Semesters) of the Four Years Multidisciplinary Undergraduate Degree Programme	100 credits
BACHELOR OF SCIENCE DEGREE at the successful completion of Three year (Six Semesters) of the Four Years Multidisciplinary Undergraduate Degree Programme.	142 credits
BACHELOR OF SCIENCE DEGREE WITH HONOURS IN EARTH SCIENCE at the successful completion of Four year (Eight Semesters) of the Four Years Multidisciplinary Undergraduate Degree Programme.	184 credits

B.Sc and B.Sc Honours in Geology

Model Programme Structure for the Bachelor of Science Degree with Geology as Major having Practicals

Sem.	Discipline Core (DSC) (Credits) (L+T+P)	Credits	Discipline Specific Elective (DSE) / Open Elective (OE) (Credits)(L+T+P)	Ability Enhancement Compulsory Courses (AECC), Languages (Credits) (L+T+P)		Skill Enhancement Courses (SEC) (L+T+P)			Total Credits
						Skill-based (Credits)	Value-based (Credits)		
I	**A1 Theory (4 credits)** Earth System Science - Fundamentals **P1 Practicals (2 credits)** -Maps, Sediment Soil, Field Visit	4+2	**OE-1 (3 credits)** i) Crystallography, Mineralogy, and Economic Minerals ii) Pedology iii) Basics of Earth System Science iv) Geohazards and Mitigation Strategies	L1-1 (3) L2-1 (3) (3+1+0) Each		Digital Fluency (2) (1+0+2)	Physical Education for fitness (1) (0+0+2)	Health and Wellness (1) (0+0+2)	25
	Discipline B1 (6)	6							
II	**A2 Theory (4 credits)** - Basics of Crystallography, Minerology and Petrology (4 credits) **P2 Practicals (2 credits)**- Crystallography, Minerology and Petrology	4 2	**OE-2 (3 credits)** i) Medical Geology ii) Industrial minerals iii) Paleobiology iv) Gems and Ornamental Stones	L1-2 (3) L2-2 (3) (3+1+0) Each	Environmental Studies (2)		Physical education-Yoga (1) (0+0+2)	NCC/NSS/R&R(S&G)/Cultural (1) (0+0+2)	25
	Discipline B2 (6)	6							
Exit option with Certificate (50 credits) A coherent understanding of Geology, ability to identify rocks and Minerals, and developing analytical skills. Its linkages with related interdisciplinary areas/subjects like Geography, Environmental Geology, Physics, Chemistry, Statistics, etc.									
III	**A3 Theory (4 credits)** - Principles of Stratigraphy Paleontology & Geology of India	4	**OE-3 (3 credits)** i) Dimensional State Technology) Climatology iii)Watershed Management iv) Marine Geology	L1-3 (3), L2-3(3) (3+1+0 each)		SEC-2: Artificial Intelligence (2)(1+0+2)	Physical education-Sports skills (1) (0+0+2)	NCC/NSS/R&R(S&G)/Cultural (1) (0+0+2)	25
	P3 Practicals (2 credits) Stratigraphy and Palaeontology	2							
	Discipline B3 (6)	6							
IV	**A4 Theory (4 credits)** - Structural Geology and Hydrogeology	4	**OE-4 (3 credits)** i) Geology and Society ii) Geostatistics iii) Geophysical Exploration iv) Geotourism	L1-4 (3), L2-4(3) (3+1+0 each)	Constitution of India (2)		Physical education-Games (1) (0+0+2)	NCC/NSS/R&R(S&G)/Cultural (1) (0+0+2)	25
	P4 Practicals (2 credits)- Water Analysis, Surveying and Thin Section Making	2							
	Discipline B4 (6)	6							
Exit option with Diploma (100 credits) The study encompasses the evolution of life through geologic time. Evolution and history of the earth and relate them to their field observations**.** Skills and ability to interpret the climatic conditions, depositional environment, identification of fossils and their evolution. Climatic history. Knowledge about surface and groundwater, its movement, methods of its exploration, its quality, methods of its conservation and recharge.									

B.Sc and B.Sc Honours in Geology

V	**A5 Theory (3 Credits)** Environmental Science, Geotectonics	3	**Vocational-1 (3 credits)** i) Remote Sensing and GIS ii) Geostatistics and Computer Applications in Earth Science iii) Water Quality and Management		SEC-3 : Cyber Security (2) (1+0+2)		20
	P5 Practicals (2 credits)- Structural Geology, Field Visit	2					
	A6 Theory (3 credits). Geochemistry, and Mining Geology	3					
	P6 Practicals (2 credits)- Ore Geology	2					
	Discipline B5 (6)	**6**					
VI	**A7 Theory (3 credits)-** Applied Geophysics	3	**Vocational-2 (3 credits)** i) Mineral Exploration and Mining ii) Medical Geology iii) Thin section making and Geological mapping		SEC-4: Professional/ Societal Communication (2)		22
	P7 Practicals (2 credits)- Applied Geophysics	2					
	A8 Theory (3 credits)- Mineral Processing including Marine Mineral Resources	3	**Internship (2 credits)** In Companies, Mines, Remote sensing Agencies				
	P8 Practicals (2 credits)- Economic Geology	2					
	Discipline B6 (6)	5					
Exit option with Bachelor of Science, B.Sc. Basic Degree (142 credits)							
VII	**A9 Theory (3 credits)-** Advanced earth systems	**3**	**DSE-1 (3 credits)** **DSE-2 (3 credits)** **Research Methodology (3 credits)**	i) Experimental petrology ii) Remote Sensing and Image Processing iii) Gemology iv) Global Change Studies v) Entrepreneurship in Geoscience vi) Medical Geology			22
	P9 Practicals (2 credits)-GIS and field visit	**2**					
	A10 Theory (3 credits)- Oceanography and Atmospheric Sciences	**3**					
	P10 Practicals (2 credits)- Image Analysis and Geostatistics	**2**					
	A11 Theory (2 credits)- Advanced Petrology	**2**					
	P11 Practicals (2 credits)- Thin Section Petrology and Petrochemistry	**2**					

B.Sc and B.Sc Honours in Geology

VIII	**A12 Theory (2 credits)**- Advanced Paleontology	**2**	**DSE-3 (3 credits)** **Research Project (6 credits) ***	i) Plate Tectonics ii) Petroleum Geology iii) Critical and Strategic Minerals of Karnataka iv) Mineral Marketing v) Hyperspectral Remote Sensing and Mineral Targeting	20
	P12 Practicals (2 credits)- Advanced Paleontology	**2**			
	A13 Theory (2 credits)- Analytical Techniques in Earth Science	**2**			
	P13 Practicals (2 credits)- X-ray, FTIR, and Spectroscopic Techniques	**2**			
	A14 Theory (3 credits)- Evaluation and Management of Mineral Deposits **OR** Nanogeoscience	**3**			
B.Sc. (Hons) degree in Geology (184 Credits)					

PROPOSED CORE SYLLABUS FOR FOUR YEARS BACHELOR OF SCIENCE (BASIC/ HONS.) DEGREE IN GEOLOGY
FIRST SEMESTER – THEORY AND PRACTICALS

GEOA1: Earth System Science Fundamentals
(Total Teaching Hours = 56; Total Credits = 4)

DISCIPLINE SPECIFIC CORE COURSE (DSC) FOR BACHELOR OF SCIENCE (BASIC/HONOURS) GEOLOGY AS MAJOR HAVING PRACTICALS

Programme/Class: **Certificate**	Year: **First**	Semester: **First**
Subject: **GEOLOGY**		
Course Code : **DSC : -GEOA1**	Course Title: **Earth System Science Fundamentals**	

Course outcomes:

After completing the course, the student will

- learn the origin of the solar system and Earth
- learn the Evolution and history of the earth and relate them to their field observations.
- understand the internal structure of Earth
- learn the Geomorphic processes; exogenetic (epigene) and endogenetic (hypogene). Landforms, & Soil –
- learn the fundamentals of geological mapping.
- learn how to read geologic maps, solve simple map problems and preparations of cross-sections.
- learn the Concept of plate tectonics
- learn earthquakes and Volcanoes

Credits: **4**	Core: **Compulsory**
Max. Marks: **60+40=100**	Min. Passing Marks: as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Units	**Topics**	**56 Hours**
1	**Introductionto EarthSystemSciences** Definition and scope of earth system sciences. Branches of Earth Sciences. Systems concepts for earth system science- fundamental concepts of the five spheres (lithosphere, hydrosphere, atmosphere, biosphere and cryosphere). Interrelationships between biological, geological, climatological, and human systems oncontinental and global scales. Anthropogenic influences on the Earth systems;Human-environmentinteractions-policy.	14

	The universe and solar system: Origin of the universe - Big bang theory. Solar system.Members of solar system – planets (Terrestrial and gaseous planets), satellite, comets,asteroids,meteorite. Earthin thesolar system.Size, shape, mass anddensityoftheearth. Origin of the Earth: Gaseous hypothesis, Nebular hypothesis, Planetesimal hypothesis, Tidal hypothesis, Supernova hypothesis, Interstellar or dust or meteoric hypothesis. Evolution ofearth. Age of the Earth: Geochronology; Absolute and relative methods;(a) Relative Methods -Sedimentation, Salinity method, varve chronology, Rate of cooling of earth. (a) Radiometricdating,atomicenergy,decayscheme,half-life,method-K-Ar; Rb-Sr;U-Pb, Pb-Pb. Ageoftheearth. Earth's internal structures and its composition. Evidence for the Earth's composition andmineralogy –1.Seismic data,2. Density studies, 3. Meteorites. Earth's internal layers-Crust, mantle and core. Lithosphere, asthenosphere, mesosphere and barysphere.	
2	**Geomorphology -I** Introduction: - Basic concepts of Geomorphology, Definition and scope, Geomorphic agents, Geomorphic processes; exogenetic (epigene) and endogenetic (hypogene). Landforms. Weathering-physical, chemical, biological. Soil-Definition,Formation,Typesofsoils.SoilProfile. Rivers and fluvial landforms: - Introduction, Development of rivers - Drainage system andpatterns. Stages of rivers – Davi's concept; youth, mature, old. Geologial actions: Erosion -hydraulic action, abrasion, attrition, solution.Erosional landforms – Pot holes, V shapedvalleys,gorgesandcanyons,waterfallsandtypes,river meanders,ox-bowlakes,riverterraces,structuralbenches.Transportation -suspension, solution.Depositionanddepositional landforms - alluvial fans and cones, flood plains, natural levees, deltas, channeldeposits. Wind and Aeolian landforms: Types of wind – Breeze, Gale, Tempest, Cyclone. Geologicalaction of wind: Wind erosion - Deflation, abrasion, attrition. Erosional features - mushroomrocks,yardangs,Hamda,ventifacts,pedestalrocks,zeugen,milletseedsands.Transportation - suspension, saltation, traction. Deposition and depositional	14

	landforms - Sand dunes andtypes,Loess.	
3	**Geomorphology -II** Glaciers and glacial landforms.Growth and movement of glaciers. Types of glaciers –Mountain or valley glaciers, Piedmont glaciers, continental ice-sheets or ice caps. Glacierimprints. Geological action of glaciers; Erosional work by glaciers – Plucking/ Excavation,Frostwedging.,Abrasion.Erosionallandforms- Whalebackforms.Glacialvalley -Ushaped valley and V-shaped valley, Crag and Tail, Hanging valley, Cirques, Fiords, Arete, Cols, Horns, Roches Moutonnes. Transportation - glacial drift.Deposition and depositionallandforms-GlacialMoraines andtypes,Drumlins,Kames, Eskers, Outwashplains,Kettles. Groundwater: - Meaning and components of groundwater. Geological action of groundwater:Erosion and erosional landforms (lapis, solution holes and associated features, poljes, cavesandcaverns:valleysofkarsttopography,naturalbridges).Transportation;solution.Depositionalwork; concretions, stalactites and stalagmites, Oceans and Coastal landforms: - Topography of ocean floor – continental slope, shelf, abyssalzone, mid-oceanic ridges. Geological action of oceans: Agents of coastal erosion; Waves,Tides, Currents and circulation of water. Process of marine erosion, erosional landforms(Headlands and Bays, Sea Cliffs, Wave-cut Terraces, Sea caves, stacks). Transportation. Depositional landforms (Beaches and barriers, wave built terraces, Spits and bars, Tombola).Deepseawaterdeposits– terrigeneousandpelagicdeposits.Corals –its types and origin.	14
4	**Geodynamics** Introduction to Geodynamics. Origin of oceans, continents and mountains. Concepts andtheoriesofisostasy.Conceptofpalaeomagnetism,applicationofpalaeomagnetism.Continental drift. Sea floor spreading. Concept of plate tectonics. Nature and types of plate margins, Midoceanic ridges and trenches. Origin and distribution of Island arcs. Earthquakes: definition, Elements of an earthquake, types	14

	of earthquake wave, intensity andmagnitude, seismographs and seismometers,causes and prediction of earthquake, Effects ofearthquake,Seismic zones ofIndia. Volcanoes: A typical volcano parts, volcanic activity, types of volcanoes, composition oflava, distribution of volcanoes. Volcanic landforms; depressed landforms: Volcanic cone(CinderCone),Volcaniccraters,Calderas(CalderaLake). Landformsduetotheaccumulationof lava:Volcanic mountains,Volcanic plateaus,Volcanic plains,Volcanicnecks.	

SUGGESTED READINGS:

1. Sarah, E., Cornell, I., Prentice, C., Joanna, I.H., Catherine, J.D., 2012. Understanding the Earth System Global Change Science for Application, Academic Press.
2. Brian, J. S., Barbara, W.M., 2010. The Blue Planet: An Introduction to Earth System Science, 3rdEdition, Wiley.
3. Ehlers, E., Krafft, T., 2006. Earth System Science in the Anthropocene, Springer.
4. Lee R. Kump, James F. Kasting, and Robert G Crane; 2004. Prentice Hall, 2nd Ed., The Earth System.
5. Jacobson, M., Charlson, R., Rodhe, H., Orians, G., 2000. Earth System Science: From Biogeochemical Cycles to Global Changes, Elsevier.
6. Jacobson, M. C., Charlson, R. J., Rodhe, H., and Orians, G. H., 2000. Earth System Science: San Diego, CA, Academic Press, 523 p., ISBN 0-12-379370-X
7. Ernst, W.G., 2000. Earth Systems: Processes and Issues, Cambridge University Press.
8. Gross, M. G. (1977). Oceanography: A view of the earth.
9. Duff, P. M. D., & Duff, D. (Eds.). 1993. Holmes' principles of physical geology. Taylor & Francis.
10. Emiliani, C. (1992). Planet earth: cosmology, geology, and the evolution of life and environment.Cambridge University Press.
11. Arthur Holmes 2016. Principles of Physical Geology–: Wiley publishers, Third edition December; ISBN- 0471072516.
12. Longwell &Flient. 1969. Physical Geology –Wiley publishers.
13. Peter J. Wyllie; 1976. The Way the Earth Works: An Introduction to the New Global Geology and Its Revolutionary Development 1st Edition.
14. Thornbury W.D.2004. Principles of Geomorphology Second Edition Paperback – 1 January CBS publishers.
15. Hugget; 2016. Fundamentals of Geomorphology by Taylor and Francis publishers.
16. Robert A. Muller 1978. Physical Geography Today: A Portrait of a

Planet –Random House publishers.

Programme/Class: **Certificate**	Year: **First**	Semester: **First**
Subject: **GEOLOGY**		
Course Code : **DSC -GEO–P1**	Course Title:**P1Practicals - Maps,SedimentSoil, FieldVisit**	

Course outcomes:

After completing the course, the student will

- learn the fundamentals of geological mapping.
- measure the geological data from the field
- learn how to read geologic maps
- interpret the geological maps
- learn the soil profile
- learn the major geomorphic features

Credits: **2**	Core: Compulsory
Max. Marks: **50+5 0=100**	Min. Passing Marks: as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P:0-0-**2**

	Topics	**30 Hours**
1	Introduction to maps. Study of maps. Types of maps. Types of scale.	1 Practical
2	Reading topographical maps of the Survey of India; Detailed study of topographic sheets.	2 Practicals
3	Preparation of topographical map	1 Practical
4	Identification of drainage patterns	2 Practical
5	Preparation of LU/LC maps	2 Practicals
6	Study of soil profile and determination of soil texture	2 Practicals
7	Study of major geomorphic features and their relationships with outcrops through physiographic models and also using lens stereoscope and mirror stereoscope.	3 Practicals
8	Field visit to a place of geological/geomorphological interest	1 Practical

OPEN ELECTIVES (OE) FOR B.SC. (HONOURS) GEOLOGY

Programme/Class: **Certificate**	Year: **First**	Semester: **First**
Subject: **GEOLOGY**		
Course Code: **GEO-OE 1**	Course Title: - **Crystallography,Mineralogy and EconomicMinerals**	

Course outcomes:

After completing the course, the student will

- learn the basics of mineralogy and crystallography helps in understanding and building the overall knowledge in Geology.
- learn the identification of minerals, in hand, their chemistry, and their types.
- learn the crystals formation, form, Symmetry, normal crystal classes, and occurrence.
- learn the formation of the mineral groups and resources.

Credits: **3**	Core: Compulsory
Max. Marks: **60+40=100**	Min. Passing Marks: as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **3**-0-0

Units	**Topics**	**48 Hours**
1	Crystals, crystalline solids and their formation; Symmetry in crystals; Axial ratio, indices,order of the crystallographic axes; Crystallographic notation (Weiss and Miller indices andconvention in notation); Classification of crystals, introduction to 32 classes; The crystalsystemsandsymmetrytypes;Stereographicrepresentationofcrystalsymmetryandtheiruses;Imperfectionofcrystalsandcrystaldefects;Twinning-causes,effectsandgenetictypes.	16
2	Isotropicandanisotropicsubstances;Reflection,refractionandrefractiveindex; double refraction; Relief, birefringence and Becke line effect; Optically uniaxial and biaxial minerals; Determination of optic sign of uniaxial and biaxial minerals;; interference colour;Pleochroism, dichroism and trichorism.	16
3	Definitionofore,oremineralandgangue;Classificationoforedeposits;Chemicalcomposition, diagnostic characters, uses and distribution in India of the following minerals:Gold, Copper, Iron, Manganese, Lead,	16

	Zinc, Bauxite, Chromite, magnesite, pyrite, diamond,muscovite,beryl,fluorite,gypsum,barite,halite,phosphorite,talc,kyanite,graphite,asbestos, monazite and corundum; Origin, uses and distribution of coal and petroleum inIndia.	

Suggested Readings:

1. Putnis A. 1992. Introduction to Mineral Sciences, Cambridge publication.
2. Cornelis Klein and Barbara Dutrow, 2007, The manual of Mineral Science, Wiley Publication
3. Phillips, F.C., 1963. An introduction to crystallography. Wiley, New York
4. Nesse, D.W., 1986. Optical Mineralogy. McGraw Hill.
5. Kerr, B.F., 1995. Optical Mineralogy 5th Ed. Mc Graw Hill, New York.
6. Ridley, John. (2013). Ore deposit geology. Cambridge University Press.
7. Barnes, H.L., 1979. Geochemistry of Hydrothermal Ore Deposits, John Wiley.
8. Mookherjee, A, 2000. Ore Genesis – A Holistic Approach. Allied Publisher.
9. Craig, J. R., and D. J. Vaughn. "Ore microscopy and ore mineralogy." (1994).
10. Pracejus, Bernhard. 2015The ore minerals under the microscope: an optical guide. Vol. 3. Elsevier.
11. Bateman, Alan Mara, and Mead L. Jensen. 1950. Economic mineral deposits. Vol. 259. New York:Wiley.

Programme/Class: **Certificate**	Year: **First**	Semester: **First**
Subject: **GEOLOGY**		
Course Code: **GEO-OE 1**	Course Title: **BasicsofEarthSystem Sciences**	

Course outcomes:

After completing the course, the student will

- learn the origin of the solar system and Earth
- understand age and the internal structure of Earth

Credits: **3**	Core: Compulsory
Max. Marks: **60+40=100**	Min. Passing Marks: as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-0-0

Units	**Topics**	**48 Hours**
1	Introduction to Earth Sciences with a special focus to Geology, scope, sub-disciplines andrelationshipwithotherbranches ofsciences	16
2	Earth in the solar system, origin Earth's size, shape, mass, density, rotational and evolutionalparameters Solar System-Introduction to Various planets - Terrestrial Planets Solar System-Introduction to Various planets - Jovian Planets Internal constitution of the earth - core, mantle andcrust	16
3	Convections in the earth's core and production of magnetic field Composition of earth in comparisontootherbodiesinthe solarsystem.Originandcomposition ofhydrosphereandatmosphere OriginofbiosphereOriginofoceans, continents andmountains Age of the earth; Radioactivity and its application in determining the age of the Earth, rocks,mineralsandfossils	16

SUGGESTEDREADINGS:

1. ArthurHolmes, 1992.PrinciplesofPhysicalGeology.Chapman& Hall.
2. Emiliani, C, 1992. Planet Earth, Cosmology, Geology and the Evolution of Life andEnvironment.CambridgeUniversityPress.
3. Gross, M.G.,1977.*Oceanography:AviewoftheEarth*,PrenticeHall.
4. D.R. Johnson, M. Ruzek, M. Kalb, 1997. what is Earth System Science? Proceedings of the 1997International Geoscience and Remote Sensing Symposium Singapore, August 4 - 8, pp 688 -691
5. Peter J. Wyllie; 1976. The Way the Earth Works: An Introduction to the New Global Geology and Its Revolutionary Development 1st Edition.

Programme/ **Certificate**	Year:**First**	Semester:**First**
Subject:**GEOLOGY**		
CourseCode: **GEOOE 1**	CourseTitle: **Geohazards and Mitigation Strategies**	

Course outcomes:

After completing the course, the student will

- study natural hazards such as landslides, floods, earthquakes and tsunamis affecting the humanity to understand the controlling processes and mitigation strategies
- understand the earth science behind natural disasters.
- understand the origin and occurrence of geohazards and evaluate the prediction and mitigations
- understand the causes, threats, impact, magnitude, and intensity of the natural hazards.
- qualitatively estimate risk, and envisage risk-appropriate mitigation strategies.
- This module has a strong societal relevance and offers huge opportunities to understand the unexpected change of nature.

Credits:**3**	Core:Compulsory
Max.Marks:**60+40=100**	Min.PassingMarks:asperrules
TotalNo.ofLectures-Tutorials-Practical(inhoursperweek):L-T-P:**3-**0-0	

Units	**Topics**	**48 Hours**
1	Geohazards: assessment and planning-Introduction, types of hazards;characteristicfeatures,occurrenceandimpactofdifferenttypes,CausesandStrategiesforMitigationofGeological Hazards; Risk assessment, Hazard maps, Land-useplanning andhazards	12
2	**Earthquakes, Mitigation Approaches:**–Earthquake, its Causes, Specific threats, Community impacts, and Mitigationstrategies. Characteristic features; Earthquake Risk Mitigation Magnitude and Intensity of earthquake; Major earthquakes; Seismic zoning; Earthquake vulnerability of India; Earthquakeriskmitigation–SeismicperformanceexaminationofRCCBuildings,retrofitting of vulnerable buildings, Construction of earthquakeresistantbuildingsfollowingproperBIScodes,Earthquakepreparedness;Casestudy–'BhujEarthquake'. **Volcanichazard**: Introduction, Types of volcanoes, Volcanic form and structure, Types of central eruption, Causes of volcanic eruptions, Volcanic	18

	products:volatiles,Volcanicproducts:pyroclasts,Volcanicproducts:lavaflows,Specificthreats, Community impacts, Volcanic hazard and predictionMitigationstrategies	
3	**Tsunami Events, Mitigation Approaches:** An introduction to Tsunami; Magnitude & Intensity of a Tsunami; Types of Tsunami; Features of Tsunamis; Prediction of Tsunamis;Tsunami HazardMitigation. **FloodandMitigationApproaches:**Typesoffloods**,**Causes offloods**,**Specificthreats**,**Communityimpacts**.**Mitigationstrategies**:**FloodplainManagement**,**FloodInsurance**,**FloodMitigation Programs**,** Property Acquisitions**,** Retrofitting FloodProneResidential Structures **Massmovements:**Soilcreepandvalleybulging,Causesoflandslides, Classification of landslides, Landslides in soilsLandslidesinrockmasses,Abriefnoteonslopestabilityanalysis. Monitoring slopes, Landslide hazard, investigation andmapping,MethodsofslopecontrolandstabilizationLandslideSpecificthreats, Communityimpacts,Mitigationstrategies.	18

SUGGESTEDREADINGS:

1. RameshP.Singh & DariusBartlett,2018.NaturalHazards:Earthquakes,Volcanoes,and Landslides.527Pages.
2. Bernard, E.N. (Ed.) 2005. Developing Tsunami-Resilient Communities: The National Tsunami Hazard Mitigation Program, Reprinted from NaturalHazards,35:1(2005),VI,186p.,ISBN:978-1-4020-3353-7.
3. Thenhaus,P.C.andCampbell,K.W., 2003.Seismichazardanalysis,in Earthquake Engineering Handbook, Chen, W. and Scawthorn, C., Eds.,CRCPress,Boca Raton,FL,
4. Bell, F.G., 1999. Geological hazards: their assessment, avoidance, andmitigation.(animprintofRoutledge).E&FNSpon,London,UK,Hardbound,ISBN0-419-16970-9;631Pages.
5. Bell, F.G. 1994. Floods and landslides in Natal and notably the greater Durban region, a retrospective view. Bulletin Association Engineering Geologists, 31, 59-74.
6. Sassa, K., Fukuoka, H., Yang, Q.J., and Wang, F.W., 1997. Landslide
7. Hazard Assessment in Cultural Heritage, Lishan, Xian, Proceedings International Symposium on Landslide Hazard Assessment, 1–24, Xian, China.
8. Alexander, D. 1993. Natural Disasters. University College London Press, London.
9. Forgione, G., Luongo, G. and Romano, R. 1989. Mt Etna (Sicily): Volcanic hazard assessment. In Volcanic Hazards: Assessment and Monitoring, Latter, J.H. (ed.), Springer-Verlag, Berlin, 137-150.

10. Broms, B. B., 1990. Landslides, Foundation Engineering Handbook, Winterkorn, H. F. and Fang, H.-Y., eds., Van Nostrand Reinhold Co.,
11. Baker, P.E. 1979. Geological aspects of volcano prediction. Journal Geological Society, 136, 341-346.
12. Bolt, B.A. 1978. Earthquakes: A Primer, W.H.Freeman, San Francisco. 11.Bolt, B.A. 1993. Earthquakes. W. H. Freeman, New York.
13. Bollinger, G. A., 1976. The seismic regime in a minor earthquake zone, Proc. ASCE Numer. Methods Geomech., 2, 917–937.
14. Hamilton, R. M., 1978. Earthquake Hazards Reduction Program-Fiscal Year 1978 Studies Supported by the U.S. Geological Survey, Geological Survey Circular 780, U.S. Dept of the Interior.
15. Bullard, R.M. (1976) Volcanoes of the Earth. University of Texas Press, Austin
16. Leeds, D. J., 1973. The Design Earthquake, in Geology, Seismicity and Environmental Impact, Special Publication Association of Engineering Geology, Los Angeles, CA.
17. Seed, H. B., 1966. A method for earthquake resistant design of earth dams, Proc. ASCE J. Soil Mech. Found. Engrg. Div., 92, 13–41.
18. Alden, W. C., 1928. Landslide and Flood at GrosVentre, Wyoming, Focus on Environmental Geology, Tank R., Ed., Oxford University Press, New York (1973), 1928, pp. 146–153.

Programme/Class: **Certificate**	Year: **First**	Semester: **Second**
Subject: **GEOLOGY**		
Course Code : **DSC/GEO -A2**	Course Title: **BasicsofCrystallography, MineralogyandPetrology**	

Course outcomes:

After completing the course, the student will

- learn the basics of mineralogy and crystallography helps in understanding and building the overall knowledge in Geology.
- exposed to the common crystals and their forms, minerals, and their basic properties especially physical and optical
- learn the most common resources viz. rocks which find tremendous applications potential especially in dimensional rock structures.
- know the common variety of rocks and minerals occurring and also their economic potential
- identification the minerals in hand their chemistry, and their types.
- learn crystals formation, form, Symmetry, normal crystal classes, and occurrence.
- learn the formation of mineral groups and resources.

Credits: **4**	Core: Compulsory
Max. Marks: **60+40=100**	Min. Passing Marks: as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4**-0-0

Units	**Topics**	**56 Hours**
1	Crystal morphology, and internal structures. Elements of crystal chemistry and aspects of crystal structures Crystal parameters and indices.Crystal symmetry and classification of crystals into six systems.	12
2	Minerals:definition and classification, physical properties and chemical composition of commonrock-forming minerals. Nature of light, Uniaxial, Biaxial, double refraction, optical accessories. Optical properties of minerals: Pleochroism, trichroism, order of interference colour. Introductiontothepetrologicalmicroscopeandidentificationofcommon rockformingminerals.	16
3	Rocks: Introduction, definition and major divisions, Forms of Igneous rocks, Intrusive, Extrusive. Texture and Structure of Igneous rocks. Tyrrell Classification of igneous rocks. Rock associations in time and space. Physical aspects of magma generation incrust and mantle. Physical properties of magmas; igneous cumulates,	16

	liquidimmiscibility,pneumatoliticaction,magmaticassimilation andmixingofmagmas. Textures of igneous rocks. Classification of igneous rocks. Igneousrockassociations.	
4	Origin,classificationandoccurrenceofsedimentaryrocks.Sedimentary textures, structures and environment.Varieties of sedimentary rocks: Siliciclastic rocks: Conglomerates, sandstones, mud rocks. Carbonate rocks, controls of carbonate deposition, components and classification of limestone, dolomite and dolomitisation Metamorphicrocks- Metamorphism,typesofmetamorphism,classificationofmetamorphicrocks, common texturesand Structures. Grades of metamorphism.	20

SUGGESTED READINGS:

1. James D Dana.2006. A Textbook of minerology,4TH edition John Wiley and Sons.
2. Verma, P. K., 2010. Optical mineralogy. Anne books Pvt. Ltd
3. Philips, FC, 2011. An Introduction to crystallography, Read books publishers.
4. Buerger, 1978. Elementary Crystallography: Introduction to the Fundamental Features of Crystals, MIT publishers.
5. Tareen Kutty, 2000. A Basic Course in Crystallography Paperback; Universities press.
6. Prasad C., 1980. A Textbook of sedimentology.
7. Tyrrel, T.W., 2019. Principles of Petrology, An introduction to the science of rocks 2nd edition Chapman and Hall, UK.
8. Turner and Verhoogen 1962. Igneous and metamorphic petrology, Allied publisher, Bombay.

Programme/Class: **Certificate**	Year: **First**	Semester: **Second**
Subject: **GEOLOGY**		
Course Code : **DSC -GEO –P2**	Course Title:**P2Practicals: Crystallography, MineralogyandPetrology**	

Course outcomes:

After completing the course, the student will

- see and feel the natural mineral
- learn to identify the mineral in hand specimens
- identification the minerals in hand their chemistry, and their types.
- learn crystals formation, form, Symmetry, normal crystal classes, and occurrence.
- learn the formation of mineral groups and resources.

Credits: **2**	Core: **Compulsory**
Max. Marks: **50+50=100**	Min. Passing Marks: as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P:0-0-**2**

	Topics	**30 Hours**
1	Measurement of interfacial angle using contact goniometer and Verification of Euler's theorem	1 Practical
2	Studyof crystals based of geometrical constants	1 Practical
3	Study of holohedral forms of six crystal system	3 Practical
4	Studyof Physical propertiesofrockformingminerals(list-givenbelow)-	5 Practical
5	Studyoftheopticalpropertiesofimportantrockformingminerals usingpolarizingmicroscope:Quartz,Plagioclase,Orthoclase,Microcline,Biotite,Hornblende,Augite,Hypersthene,Olivine,Garnet, Calcite.	1 Practical
6	Visitto field tostudythemode ofoccurrenceof minerals.	2 Practicals
7	Rock Identification: Igneous rocks -Plutonic, Hypobysal and Volcanic. Representative rocks and textures. Sedimentary Rocks- Representative rocks, Basic structures observed in sedimentary rocks. Metamorphic rocks-Representative rocks types representing all the grades of metamorphism.	3 Practicals

Silicates*	Non-silicates				Native elements
	Non-Metallicminerals		Metallicminerals		
Important rockforming mineral sandallare silicabearing minerals	Hydroxides	-	Hydroxides	Bauxite,Psilomelane	Sulphur ,Graphite
	Sulphates	Barite,Gypsum	Sulphides	Chalcopyrite, GalenaRealgar,Orpiment,Spalerite(&dodecahedral),Cinnabar, Pyrite,Stibnite	
	Oxides	Corundum	Oxides	Haematite(&botryoidal ,micaceous),Magnetite , Pyrolusite,Chromite	
	Carbonates	Dolomite, Calcite, Magnesite	Carbonates	Malachite,Azurite	
	Phosphates	Monazite			
	Halides	Rocksalt (Halite),Fluorite			

*Silicates		**Group**	**MineralName**
Nesosilicates		OlivineGroup	Olivine
		GarnetGroup	Garnet
		Al_2SiO_5Group	Andalusite,Sillimanite,Kyanite,Staurolite
		ZirconGroup	Zircon
Sorosilicates		EpidoteGroup	-
Cyclosilicates		BerylGroup	Beryl
		Tourmaline	Tourmaline
Inosilicates	Single Chain Silicates	PyroxeneGroup	Augite,Hypersthene
	Double Chain Silicates	AmphiboleGroup	Actinolite,Hornblende
Phyllosilicates		SerpentineGroup	Serpentine,Asbestos
		ClayMinerals Group	Talc,Kaolin
		MicaGroup	Muscovite,Biotite,Phlogopite,Vemiculite
Tectosilicates		QuartzGroup	Quartz
		FeldsparGroup	Orthoclase,Plagioclase,Microcline
		FeldspathoidGroup	Nepheline,Sodalite
		ZeoliteGroup	Zeolite

Programme/Class: **Certificate**	Year: **First**	Semester: **Second**
Subject: **GEOLOGY**		
Course Code: **GEO -OE 2**	Course Title: **IndustrialMinerals**	

Course outcomes:

After completing the course, the student will

- learn the principles of rock formation including minerals genesis during the rock formation and after their formati
- have skills to work in quarrying, mining, rock polishing, cement, silica/glass, sand mining, brick, ceramic, pottery, and refractory industries.
- exposed to start their entrepreneurship.
- benefited work/carry research in the interdisciplinary science to get original ideas and look for new reserves.

Credits: **3**	Core: Compulsory
Max. Marks: **60+40=100**	Min. Passing Marks: as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week):
L-T-P: **3**-0-0

Units	**Topics**		**48 Hours**
1	**IntroductiontoMineralsandRocks** Introductiontorockformingandeconomicallyimportant minerals.Principles of rock cycle, origin and classification of economicallyimportantmineraldeposits.		10
2	**Propertiesof mineralsandrocks,andtheiroccurrences:** Physical properties, chemical composition, and diagnostic criteria forthe identification of minerals. Ore minerals and gangue minerals, tenorand grade of the ore for industrial processing of minerals. Selectioncriteria followed for quarrying of decorative and dimensional rockblocks/slabs.Nationalmineralpolicy		14
3	**Properties, occurrences and distribution of the followingminerals/rocksinIndia,withspecialreferencetoKarnataka**:		
	Industry	**Minerals**	22

	Jewelry	gold,diamonds,preciousminerals,corals,pearlandopals,sapphires,rubies, and emeralds	
	Metallic	Bauxite,chromite,ilmenite,magnetite,hematite, sphalerite, galena, chalcopyrite, pyrolusite	
	Cementand Refractoryminerals	Calcite,limestone,gypsum,clayminerals, magnesite, graphite, chalk, marble, dolomite,zircon,kaolin,magnesiaandaluminaminerals,	
	Ceramicsand glass	clayminerals,kaolinite,silicasandandbauxite, limestoneandfeldspar.	
	Abrasives,and rockandmineral polishing	industrialdiamond,corundum,garnetandquartz, magnesite,pumice, anddiatomaceousearth	
	Electronicand electrical	rareearthelements,mica,wolframite,native metallic minerals, ores of copper, aluminium,	
	Strategic/defense	rare earth elements, Ilmenite, monazite, mica,vanadium from magnetite, poly metallic nodulesandrockencrustationintheoceantoextractcobalt andnickel	
	Chemicalsandfertilizers	Barite, calcite, magnesite, asbestos, diatomite, feldspar, gypsum, kaolinite,phosphorite,mica, talc,zeolite, bauxite, chromite, ilmenite, magnetite,hematite, sphalerite, galena, clay mineralschalcopyrite,pyrolusite,pyriteandmonazite	

	Dimensionalandd ecorative rocks&dimension al stones	Marble,granites,gneiss,doleri te,phylllite,slate,sandstones,s and,gravel,pebbleandboulde rs.	
	Nanotechnology:	Clayminerals,ilmenite,polym orphsof carbon, titanium and anhydrous iron oxide minerals andmineralcompositeforrare mineralsubstitutes	

SUGGESTEDREADINGS:

1. National Mineral Policy, 2019. approved by Cabinet of the Government of India.
2. https://pib.gov.in/Pressreleaseshare.aspx?PRID=1566733.
3. Klein, C and Philpotts 2016. Earth Materials Introduction to Mineralogy and Petrology Cambridge University Press.
4. Jensen M.L. and Bateman, A. 2013. Economic Mineral Deposits, John Wiley & Sons; Revised Edition.
5. Mineral Distribution in India.
6. http://ismenvis.nic.in/KidsCentre/Mineral_Distribution_in_India_13948.aspx.
7. Jetli, K.N. and Narindar, K.J., 2011. Mineral Resources and Policy in India.
8. Mineral scenarios of India https://ibm.gov.in/writereaddata/files/09182018162439Mineral%20Scenario%20pdf.pdf.
9. Unlocking India's Mineral Wealth https://mines.gov.in/writereaddata/UploadFile/GSI_PDAC_2013.pdf

Programme/Class: **Certificate**	Year: **First**	Semester: **Second**
Subject: **GEOLOGY**		
Course Code: **GEO -OE 2**	Course Title: **Paleobiology**	

Course outcomes:

After completing the course, the student will

- understand fossils, types, fossilization process and modes of preservation.
- learn invertebrate and vertebrate fossils which help to unravel the mystery of life in the past.
- understand the evolution of life on earth.
- learn rich mineral deposits like petroleum, coal, and other minerals.

Credits: **3**	Core: Compulsory
Max. Marks: **60+40=100**	Min. Passing Marks: as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P**: 3**-0-0

Units	**Topics**	**48 Hours**
1	**Fossil**: Definition, Classification, types of fossils, Fossilization process and Modes of Preservation: Fossils of soft parts, fossils of hard parts, unaltered hard parts, altered hard parts (Molds & Casts, Petrifaction: Permineralization& Replacement, and Carbonisation); and indirect fossils (Imprints, Traces of Biological Activity :Tracks, Trails and Burrows).	12
2	**Invertebrate and Vertebrate Fossils: Definition** Study of the following groups of invertebrate fossils – Morphology, classification and geological distribution of important fossils Coelenterata, Brachiopods, Mollusca, Echinodermata, Arthropoda.	16
3	**Plant Fossils**: Classification of Plants. Plant fossils through ages. Gondwana flora and their significance. Microfossils: Classification of Microfossils, Foraminifera and Ostracoda.	20

SUGGESTEDREADINGS:

1. Sreepat Jain,2017. Fundamentals of Invertebrate Paleontology Macrofossils. This Springer imprint is published by Springer Nature.
2. Jain, P.C. and Anantharaman, M.S, 2016. Paleontology (Palaeobiology). Evolution and Animal Distribution, Vishal Publications.

3. Michael J. Benton & David A. T. Harper, 2009. Introduction to Palaeobiology and the Fossil Record. Wiley –Blackwell, John Wiley & Sons, Ltd., Publication
4. AmalDasgupta, 2005. Introduction to Paleontology, The world Press Private Limited, Kolkata.
5. Prothero Donald R., 2004. Bringing Fossils to Life: An Introduction to Paleobilogy, 2nd edition, McGraw Hill, Higher Education.
6. Moore, R.C., Lalicker, C.G., Fischer, A.G, 2004: Invertebrate fossils. McGraw, Hill, Book Co,
7. Romer, A.S. 2004. Vertebrate Palaeontology, (3rd edition). Chicago University Press.
8. Shrock, R.A. 2002. Principles of Invertebrate Paleontology. Twenhofel. Company, Ltd.
9. John Pojeta, Jr. Dale A. Springer, 2001. Evolution and Fossil Record. American Geological Institute, The Paleontological Society. Printing: CLB Printing
10. Ruap, D.M, Stanley, S.M, 1999. Principles of Palaeontology. W.H. Freeman and Co, Toppan Co. Ltd
11. Woods H, 1982. Paleontology Invertebrate. CBS Publications and distributors.
12. McAlester, L.A, 1969. History of life. Prentice Hall Inc.,

Programme/Class:**Certificate**	Year: **First**	Semester: **Second**
Subject: **GEOLOGY**		
Course Code: **GEO -OE 2**	Course Title: **Medical Geology**	

Course outcomes:

After completing the course, the student will

- exposure to metal ions and their analysis,
- metal ions in environment,
- biological risk assessment studies,
- modern methods of trace element analysis,
- understand public health and relevance to the Ayush Programme of the Government of India
- understand the importance of geology in health and disease,
- understand the extent, patterns and consequences of exposure to metal ions and analysis, Metal ions in environment, biological risk assessment studies.

Credits: **3**	Core: Compulsory
Max. Marks: **60+40=100**	Min. Passing Marks: as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week):
L-T-P**: 3**-0-0

Units	**Topics**	**48 Hours**
1	**Foundations of medical geology:** Ancient findings, more recent findings, Environmental classification of elements in relation to public health; inorganic poisons affecting public health in addition to pathogens with some examples from India; developments in medical geology, **Environmental biology** Distribution of elements in Nature - A chemically variable earth; Mineral chemistry, diversity in the composition of rocks, biogeochemical cycle, establishing geochemical baselines, geochemical baseline map of India, Total composition and bioavailability, integrating epidemiological research with high quality geochemical composition of drinking water and food, agriculture and forest management.	12
2	**Anthropogenic sources of contaminating elements**: Mining, Mineral processing and metal refining; power generation, other industrial activities, waste disposal, agricultural practices, contamination from transport industry, atmospheric deposition of contaminants, contamination in urban environment, treatment and	16

	transport of drinking water. **Uptake of elements from chemical biological points of view, bioavailability of elements in soil** Gain knowledge about the medicinal value of various minerals by understanding the physical and chemical properties. Study the minerals that have health benefits or cause harm **Geological impacts on nutrition** Geological sources of nutrient elements, quantitative estimates of mineral needs, clinical assessment of mineral status, ecological aspects of mineral nutrients	
3	**Pathways of exposure** Volcanic emissions and health, radon and U in water, Arsenic in water and environment, fluoride in drinking and irrigation water, health effects of hardness of water, selenium and iodine deficiency, selenium toxicity **Geophagy; Soil borne pathogens** **Natural aerosolic mineral dusts and human health –** dust storms, pneumoconiosis, lung diseases, silicosis, asbestosis tuberculosis **Quality of groundwater** **Thresholds for metal and non-metal ions from health point of view: as prescribed by:** WHO, Bureau of Indian Standards, other international standards, AERB India, Methods of analysis of risk factors.	20

SUGGESTEDREADINGS:

1. Selinus, Olle (Ed.), 2013, Essential of Medical Geology, Revised Edition. Springer.
2. Syed E. Hasan, 2020, Medical Geology, PMCID publications.
3. Carlos-Alberto Ríos-Reyes, María-Paula Ríos-Gutiérrez and Santiago Joya-Neira, Archivos de MedicinaVolumen, 2021, The importance of minerals in medical geology: impacts of the environment on health. Enero-Junio de.

ABILITY ENHANCEMENT COMPULSORY COURSES (AECC),
B.Sc., (Basic & Hons) GEOLOGY
II SEMESTER,AECC – ENVIRONMENTAL STUDIES

Programme/Class: **Certificate**	Year: **First**	Semester: **Second**
Subject: **GEOLOGY**		
Course Code: **GEO- AECC-2**	Course Title: **Environmental Studies**	

Course outcomes:
After completing the course, the student will

- Learn the sustainable development
- Understand the Ecosystem
- Learn the concept of Renewable and Non-renewable resources,
- Understand the Biodiversity and and its conservation
- Learn the Environmental pollution, policy and practices
- Learn the Human Population Growth

Credits: **2**	Core: Compulsory
Max. Marks: **60+40+100**	Min. Passing Marks: as per rules
Total No.of Lectures-Tutorials-Practical (in hours per week):L-T-P:**2**-0-0	

Units	**Topics**	**Hours 45**
1	**Introduction to environmental studies**: Multidisciplinary nature of environmental studies; Scope and importance; Concept of sustainability and sustainable development.	2
2	**Ecology and Ecosystems** Concept of ecology and ecosystem, Structure and function of ecosystem; Energy flow in an ecosystem; food chains, food webs; Basic concept of population and community ecology; ecological succession. Characteristic features, structure and function of the following ecosystem: a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic ecosystems (ponds, streams, lakes, rivers, ocean estuaries	6
3	**Natural Resources:** Concept of Renewable and Non-renewable resources,	8

	Land resources and landuse change; Land degradation, soil erosion and desertification. Deforestation: Causes, consequences and remedial measures. Water: Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter-state). Energy resources: Environmental impacts of energy generation, use of alternative and nonconventional energy sources, growing energy needs	
	Biodiversity and its conservation Levels of biological diversity: genetic, species and ecosystem diversity; Biogeographic zones of India; Biodiversity patterns and global biodiversity hot spots India as a mega-biodiversity nation; Endangered and endemic species of India Threats to biodiversity: Habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions; Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity. Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value	
	Environmentalpollution: concepts and types.Air, water, soil, noise and marine pollution- causes, effects and controls, Concept of hazards waste and human health risks , Solid waste management: Control measures of Municipal, biomedical and e-waste	
	Environmental Policies and Practices: Climate change, global warming, ozone layer depletion, acid rain and their impacts on human communities and agriculture Environment Laws: Wildlife Protection Act; Forest Conservation Act. Water (Prevention and control of Pollution) Act; Air (Prevention & Control of Pollution) Act; Environment Protection Act; Biodiversity Act. International agreements: Montreal Protocol, Kyoto protocol and climate negotiations; Convention on Biological Diversity (CBD). Protected area network, tribal populations and rights, and human wildlife conflicts in Indian context.	
	Human population growth: Impacts on environment, human health and welfare. Resettlement and rehabilitation of people; its problems and concerns.	

	Environmental Disaster: Natural Disasters-floods, earthquake, cyclones, tsunami and landslides; Manmade Disaster- Bhopal and Chernobyl. Environmental movements: Bishnois.Chipko, Silent valley,Big dam movements. Environmental ethics: Role of gender and cultures in environmental conservation. Environmental education and public awareness	

SUGGESTEDREADINGS

1. Asthana, D. K. 2006. Text Book of Environmental Studies. S. ChandPublishing.
2. Basu, M., Xavier, S. 2016.. Fundamentals of Environmental Studies, CambridgeUniversity Press,India.
3. Basu, R. N., (Ed.) (2000). Environment. University of Calcutta, Kolkata.
4. Bharucha, E. (2013). Textbook of Environmental Studies for Undergraduate Courses.Universities Press.
5. De, A.K., (2006). Environmental Chemistry, 6th Edition, New Age International, NewDelhi.
6. Mahapatra, R., Jeevan, S.S., Das, S. (Eds) (2017). Environment Reader for Universities,Centre forScience and Environment, New Delhi.
7. Masters, G. M., &Ela, W. P. (1991). Introduction to environmental engineering and science.Englewood Cliffs, NJ: Prentice Hall.
8. Mitra, A. K and Chakraborty, R., 2016. Introduction to Environmental Studies, Book Syndicate,
9. Enger, E. and Smith, B., 2010. Environmental Science: A Study of Interrelationships, Publisher: McGraw-Hill Higher Education; 12th edition.