FYUGP

GEOLOGY HONOURS/ RESEARCH

FOR UNDER GRADUATE COURSES UNDER RANCHI UNIVERSITY

Upgraded & Implemented from 3rd Semester of Academic Session 2022-26
& From 1st Semester of Session 2023-27 Onwards

UNIVERSITY DEPARTMENT OF GEOLOGY

A DST-FIST SPONSORED DEPARTMENT

Ranchi University, Ranchi - 834008 (Jharkhand)

Ref. No. : PG/GL-269/2023 Date : 18/05/2023

RANCHI UNIVERSITY, RANCHI

BOARD OF STUDIES FOR B.Sc. GEOLOGY (2022-2026)

A meeting of the Board of Studies was held on 18/05/2023 at 10:00 a.m. in the University Department of Geology, Ranchi University, Ranchi under the guidance of Prof. (Dr.) Bijay Singh, Head, University Department of Geology to modify the syllabus of the Four Year Under-Graduate Programme (FYUGP) according to NEP-2020. The syllabus is thoroughly discussed and modifications were suggested by the members present in the meeting. In light of the suggestions of the members, the draft of the syllabus is prepared and approved. The following Members/External Members were present in the meeting:

A. Chairperson:

1. Prof. (Dr.) Bijay Singh
   Head, University Deptt of Geology, R.U.

B. Internal Members:

1. Dr. Chakradhar Prasad Mahto
   Asst. Professor, University Dept. of Geology, R.U.
2. Dr. Chanchal Lakra
   Asst. Prof., University Dept. of Geology, R.U.
3. Dr. Suresh Kumar Samad
   Asst. Prof., University Dept. of Geology, R.U.
4. Mr. Amit Kumar
   Asst. Prof., University Dept. of Geology, R.U.

C. External Experts:

5. Mrs. N. P. Tirkey – Absent
   PGRU
1. Prof. Arvind Kumar Pandeya
   Dean, Faculty of Science, N.P.U.
   External Expert
2. Mr. Amaresh Chandra Mishra
   Head, Gossner College, Ranchi
   External Expert
3. Dr. Nitish Priyadarshi
   Asst. Professor, University Department of Geology, R.U.
   Alumnus Member

D. Invited Member:

1. Dr. Neeraj
   Assistant Professor, University Dept. of Chemistry, RU
   Invited Expert Member.

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DIRECTOR
IQAC, RANCHI UNIVERSITY
RANCHI-834 001

Head
University Department of Geology
Ranchi University, Ranchi

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Students are Instructed to

Refer Syllabus of Allied/ Opted Subjects from R.U. Website

HIGHLIGHTS OF REGULATIONS OF FYUGP

PROGRAMME DURATION

- The Full-time, Regular UG programme for a regular student shall be for a period of four years with multiple entry and multiple exit options.
- The session shall commence from **1st of July**.

ELIGIBILITY

- The selection for admission will be primarily based on availability of seats in the Major subject and marks imposed by the institution. Merit point for selection will be based on marks obtained in Major subject at Class 12 (or equivalent level) or the aggregate marks of Class 12 (or equivalent level) if Marks of the Major subject is not available. Reservation norms of The Government of Jharkhand must be followed as amended in times.
- UG Degree Programmes with Double Major shall be provided only to those students who secure a minimum of overall 75% marks (7.5 CGPA) or higher.
- Other eligibility criteria including those for multiple entry will be in light of the UGC Guidelines for Multiple Entry and Exit in Academic Programmes offered in Higher Education Institutions.

ADMISSION PROCEDURE

- The reservation policy of the Government of Jharkhand shall apply in admission and the benefit of the same shall be given to the candidates belonging to the State of Jharkhand only. The candidates of other states in the reserved category shall be treated as General category candidates. Other relaxations or reservations shall be applicable as per the prevailing guidelines of the University for FYUGP.

VALIDITY OF REGISTRATION

- Validity of a registration for FYUGP will be for maximum for Seven years from the date of registration.

ACADEMIC CALENDAR

- An Academic Calendar will be prepared by the university to maintain uniformity in the CBCS of the UG Honours Programmes, UG Programmes, semesters and courses in the college run under the university (Constituent/Affiliated).
- **Academic Year:** Two consecutive (one odd + one even) semesters constitute one academic year.
- **Semester:** The Odd Semester is scheduled from **July to December** and the Even Semester is from **January to June**. Each week has a minimum of 40 working hours spread over 6 days.
- Each semester will include – Admission, course work, conduct of examination and declaration of results including semester break.
- In order to undergo 8 weeks' summer internship/ apprenticeship during the summer camp, the Academic Calendar may be scheduled for academic activities as below:
  a) Odd Semester: **From first Monday of August to third Saturday of December**
  b) Even Semester: **From first Monday of January to third Saturday of May**
- An academic year comprising 180 working days in the least is divided into two semesters, each semester having at least 90 working days. With six working days in a week, this would mean that each semester will have 90/ 6 = 15 teaching/ working weeks. Each working week will have 40 hours of instructional time.
- Each year the University shall draw out a calendar of academic and associated activities, which shall be

strictly adhered to. The same is non-negotiable. Further, the Department will make all reasonable endeavors to deliver the programmes of study and other educational services as mentioned in its Information Brochure and website. However, circumstances may change prompting the Department to reserve the right to change the content and delivery of courses, discontinue or combine courses and introduce or withdraw areas of specialization.

PROGRAMME OVERVIEW/ SCHEME OF THE PROGRAMME

- Undergraduate degree programmes of either 3 or 4-year duration, with multiple entries and exit points and re-entry options within this period, with appropriate certifications such as:
  - UG Certificate after completing 1 year (2 semesters) of study in the chosen fields of study provided they complete one vocational course of 4 credits during the summer vacation of the first year or internship/ Apprenticeship in addition to 6 credits from skill-based courses earned during first and second semester.,
  - UG Diploma after 2 years (4 semesters) of study diploma provided they complete one vocational course of 4 credits or internship/ Apprenticeship/ skill based vocational courses offered during first year or second year summer term in addition to 9 credits from skill-based courses earned during first, second, and third semester,
  - Bachelor's Degree after a 3-year (6 semesters) programme of study,
  - Bachelor's Degree (Honours) after a 4-year (8 semesters) programme of study.
  - Bachelor Degree (Honours with Research) after a 4-year (8 semesters) programme of study to the students undertaking 12 credit Research component in fourth year of FYUGP.

CREDIT OF COURSES

The term 'credit' refers to the weightage given to a course, usually in terms of the number of instructional hours per week assigned to it. The workload relating to a course is measured in terms of credit hours. It determines the number of hours of instruction required per week over the duration of a semester (minimum 15 weeks).

a) One hour of teaching/ lecture or two hours of laboratory /practical work will be assigned per class/interaction.
   One credit for Theory = 15 Hours of Teaching i.e., 15 Credit Hours
   One credit for Practicum = 30 Hours of Practical work i.e., 30 Credit Hours

b) For credit determination, instruction is divided into three major components:
   Hours (L) – Classroom Hours of one-hour duration.
   Tutorials (T) – Special, elaborate instructions on specific topics of one-hour duration
   Practical (P) – Laboratory or field exercises in which the student has to do experiments or other practical work of two-hour duration.

CALCULATION OF MARKS FOR THE PURPOSE OF RESULT

- Student's final marks and the result will be based on the marks obtained in Semester Internal Examination and End Semester Examination organized taken together.
- Passing in a subject will depend on the collective marks obtained in Semester internal and End Semester University Examination both. However, students must pass in Theory and Practical Examinations separately.

PROMOTION CRITERIA

First degree programme with single major:

i. The Requisite Marks obtained by a student in a particular subject will be the criteria for promotion to the next Semester.
ii. No student will be detained in odd Semesters (I, III, V & VII).
iii. To get promotion from Semester-II to Semester-III a student will be required to pass in at least 75% of Courses in an academic year, a student has to pass in minimum 9 papers out of the total 12 papers.
iv. To get promotion from Semester-IV to Semester-V (taken together of Semester I, II, III & IV) a student has to pass in minimum 18 papers out of the total 24 papers.
v. To get promotion from Semester-VI to Semester-VII (taken all together of Semester I, II, III, IV, V & VI) a student has to pass in minimum 26 papers out of the total 34 papers.
vi. However, it will be necessary to procure pass marks in each of the paper before completion of the course.

First degree programme with dual major:

vii. Above criterions are applicable as well on the students pursuing dual degree programmes however first degree programme will remain independent of the performance of the student in dual major courses.
viii. To get eligible for taking ESE, a student will be required to pass in at least 75% of Courses in an academic year.
ix. A student has to pass in minimum 3 papers out of the total 4 papers.
x. It will be a necessity to clear all papers of second major programme in second attempt in succeeding session, failing which the provision of dual major will be withdrawn and the student will be entitled for single first degree programme.

PUBLICATION OF RESULT

- The result of the examination shall be notified by the Controller of Examinations of the University in different newspapers and also on University website.
- If a student is found indulged in any kind of malpractice/ unfair means during examination, the examination taken by the student for the semester will be cancelled. The candidate has to reappear in all the papers of the session with the students of next coming session and his one year will be detained. However, marks secured by the candidate in all previous semesters will remain unaffected.
- There shall be no Supplementary or Re-examination for any subject. Students who have failed in any subject in an even semester may appear in the subsequent even semester examination for clearing the backlog. Similarly, the students who have failed in any subject in an odd semester may appear in the subsequent odd semester examination for clearing the backlog.

Regulation related with any concern not mentioned above shall be guided by the Regulations of the University for FYUGP.

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COURSE STUCTURE FOR FYUGP **'HONOURS/ RESEARCH'**

Table 1: Credit Framework for Four Year Undergraduate Programme (FYUGP) under State Universities of Jharkhand [Total Credits = 160]

Level of Courses	**Semester**	**MJ**; Discipline Specific Courses – Core or Major (80)	**MN**; Minor from discipline (16)	**MN**; Minor from vocational (16)	**MDC**; Multidisciplinary Courses [Life sciences, Physical Sciences, Mathematical and Computer Sciences, Data Analysis, Social Sciences, Humanities, etc.] (9)	**AEC**; Ability Enhancement Courses (Modern Indian Language and English) (8)	**SEC**; Skill Enhancement Courses (9)	**VAC**; Value Added Courses (6)	**IAP**; Internship/ Dissertation (4)	**RC**; Research Courses (12)	**AMJ**; Advanced Courses in lieu of Research (12)	**Credits**	**Double Major (DMJ)**
1	2	3	4	5	6	7	8	9	10	11	12	13	14
100-199: Foundation or Introductory courses	**I**	4	4		3	2	3	4				**20**	4+4
	II	4+4		4	3	2	3					**20**	4+4
	Exit Point: Undergraduate Certificate provided with Summer Internship/ Project (4 credits)												
200-299: Intermediate-level courses	**III**	4+4	4		3	2	3					**20**	4+4
	IV	4+4+4		4		2		2				**20**	4+4
	Exit Point: Undergraduate Diploma provided with Summer Internship in 1st or 2nd year/ Project (4 credits)												
300-399: Higher-level courses	**V**	4+4+4	4						4			**20**	4+4
	VI	4+4+4+4		4								**20**	4+4
	Exit Point: Bachelor's Degree												
400-499: Advanced courses	**VII**	4+4+4+4	4									**20**	4+4
	VIII	4		4						12	4+4+4	**20**	4+4
	Exit Point: Bachelor's Degree with Hons. /Hons. with Research											**160**	**224**

Note: Honours students not undertaking research will do 3 courses for 12 credits in lieu of a Research project / Dissertation.

Upgraded & Implemented from 3rd Sem. of Session 2022-26 & 1st Sem. of Session 2023-27 Onwards

Table 2: Semester wise Course Code and Credit Points for Single Major:

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		
	Code	**Papers**	**Credits**
I	AEC-1	Language and Communication Skills (MIL 1 - Hindi/ English)	2
	VAC-1	Value Added Course-1	4
	SEC-1	Skill Enhancement Course-1	3
	MDC-1	Multi-disciplinary Course-1	3
	MN-1A	Minor from Discipline-1	4
	MJ-1	Major paper 1 (Disciplinary/Interdisciplinary Major)	4
II	AEC-2	Language and Communication Skills (MIL 2 - English/ Hindi)	2
	SEC-2	Skill Enhancement Course-2	3
	MDC-2	Multi-disciplinary Course-2	3
	MN-2A	Minor from Vocational Studies/Discipline-2	4
	MJ-2	Major paper 2 (Disciplinary/Interdisciplinary Major)	4
	MJ-3	Major paper 3 (Disciplinary/Interdisciplinary Major)	4
III	AEC-3	Language and Communication Skills (Language Elective 1 - Modern Indian language including TRL)	2
	SEC-3	Skill Enhancement Course-3	3
	MDC-3	Multi-disciplinary Course-3	3
	MN-1B	Minor from Discipline-1	4
	MJ-4	Major paper 4 (Disciplinary/Interdisciplinary Major)	4
	MJ-5	Major paper 5 (Disciplinary/Interdisciplinary Major)	4
IV	AEC-3	Language and Communication Skills (Language Elective - Modern Indian language including TRL)	2
	VAC-2	Value Added Course-2	2

	MN-2B	Minor from Vocational Studies/Discipline-2	4
	MJ-6	Major paper 6 (Disciplinary/Interdisciplinary Major)	4
	MJ-7	Major paper 7 (Disciplinary/Interdisciplinary Major)	4
	MJ-8	Major paper 8 (Disciplinary/Interdisciplinary Major)	4
V	MN-1C	Minor from Discipline-1	4
	MJ-9	Major paper 9 (Disciplinary/Interdisciplinary Major)	4
	MJ-10	Major paper 10 (Disciplinary/Interdisciplinary Major)	4
	MJ-11	Major paper 11 (Disciplinary/Interdisciplinary Major)	4
	IAP	Internship/Apprenticeship/Field Work/Dissertation/Project	4
VI	MN-2C	Minor from Vocational Studies/Discipline-2	4
	MJ-12	Major paper 12 (Disciplinary/Interdisciplinary Major)	4
	MJ-13	Major paper 13 (Disciplinary/Interdisciplinary Major)	4
	MJ-14	Major paper 14 (Disciplinary/Interdisciplinary Major)	4
	MJ-15	Major paper 15 (Disciplinary/Interdisciplinary Major)	4
VII	MN-1D	Minor from Discipline-1	4
	MJ-16	Major paper 16 (Disciplinary/Interdisciplinary Major)	4
	MJ-17	Major paper 17 (Disciplinary/Interdisciplinary Major)	4
	MJ-18	Major paper 18 (Disciplinary/Interdisciplinary Major)	4
	MJ-19	Major paper 19 (Disciplinary/Interdisciplinary Major)	4
VIII	MN-2D	Minor from Vocational Studies/Discipline-2	4
	MJ-20	Major paper 20 (Disciplinary/Interdisciplinary Major)	4
	RC/ AMJ-1 AMJ-2 AMJ-3	Research Internship/Field Work/Dissertation OR Advanced Major paper-1 (Disciplinary/Interdisciplinary Major) Advanced Major paper-2 (Disciplinary/Interdisciplinary Major) Advanced Major paper-3 (Disciplinary/Interdisciplinary Major)	12/ 4 4 4
		Total Credit	**160**

NUMBER OF CREDITS BY TYPE OF COURSE

The hallmark of the new curriculum framework is the flexibility for the students to learn courses of their choice across various branches of undergraduate programmes. This requires that all departments prescribe a certain specified number of credits for each course and common instruction hours (slot time).

Table 3: Overall Course Credit Points for Single Major

Courses	Nature of Courses	3 yr UG Credits	4 yr UG Credits
Major	Core courses	60	80
Minor	i. Discipline/ Interdisciplinary courses and ii. Vocational Courses	24	32
Multidisciplinary	3 Courses	9	9
AEC	Language courses	8	8
SEC	**Courses to be developed by the University**	9	9
Value Added Courses	Understanding India, Environmental Studies, Digital Education, Health & wellness, Summer Internship/ Apprenticeship/ Community outreach activities, etc.	6	6
Internship (In any summer vacation for Exit points or in Semester-V)		4	4
Research/ Dissertation/ Advanced Major Courses	Research Institutions/ 3 Courses		12
	Total Credits =	**120**	**160**

Table 4: Overall Course Code and Additional Credit Points for Double Major

Courses	Nature of Courses	3 yr UG Credits	4 yr UG Credits
Major 1	Core courses	60	80
Major 2	Core courses	48	64
Minor	i. Discipline/ Interdisciplinary courses and ii. Vocational Courses	24	32
Multidisciplinary	3 Courses	9	9
AEC	Language courses	8	8
SEC	**Courses to be developed by the University**	9	9
Value Added Courses	Understanding India, Environmental Studies, Digital Education, Health & wellness, Summer Internship/ Apprenticeship/ Community outreach activities, etc.	6	6
Internship (In any summer vacation for Exit points or in Semester-V)		4	4
Research/ Dissertation/ Advanced Major Courses	Research Institutions/ 3 Courses		12
	Total Credits =	**168**	**224**

Table 5: Semester wise Course Code and Additional Credit Points for Double Major:

Semester	Double Major Courses		
	Code	Papers	Credits
I	DMJ-1	Double Major paper-1 (Disciplinary/Interdisciplinary Major)	4
	DMJ-2	Double Major paper-2 (Disciplinary/Interdisciplinary Major)	4
II	DMJ-3	Double Major paper-3 (Disciplinary/Interdisciplinary Major)	4
	DMJ-4	Double Major paper-4 (Disciplinary/Interdisciplinary Major)	4
III	DMJ-5	Double Major paper-5 (Disciplinary/Interdisciplinary Major)	4
	DMJ-6	Double Major paper-6 (Disciplinary/Interdisciplinary Major)	4
IV	DMJ-7	Double Major paper-7 (Disciplinary/Interdisciplinary Major)	4
	DMJ-8	Double Major paper-8 (Disciplinary/Interdisciplinary Major)	4
V	DMJ-9	Double Major paper-9 (Disciplinary/Interdisciplinary Major)	4
	DMJ-10	Double Major paper-10 (Disciplinary/Interdisciplinary Major)	4
VI	DMJ-11	Double Major paper-11 (Disciplinary/Interdisciplinary Major)	4
	DMJ-12	Double Major paper-12 (Disciplinary/Interdisciplinary Major)	4
VII	DMJ-13	Double Major paper-13 (Disciplinary/Interdisciplinary Major)	4
	DMJ-14	Double Major paper-14 (Disciplinary/Interdisciplinary Major)	4
VIII	DMJ-15	Double Major paper-15 (Disciplinary/Interdisciplinary Major)	4
	DMJ-16	Double Major paper-16 (Disciplinary/Interdisciplinary Major)	4
		Total Credit	**64**

Abbreviations:

AEC	Ability Enhancement Courses
SEC	Skill Enhancement Courses
IAP	Internship/Apprenticeship/ Project
MDC	Multidisciplinary Courses
MJ	Major Disciplinary/Interdisciplinary Courses
DMJ	Double Major Disciplinary/Interdisciplinary Courses
MN	Minor Disciplinary/Interdisciplinary Courses
AMJ	Advanced Major Disciplinary/Interdisciplinary Courses
RC	Research Courses

AIMS OF BACHELOR'S DEGREE PROGRAMME IN GEOLOGY

The broad aims of bachelor's degree programme in Geology are:

1. The curriculum of B.Sc. (Hons) Geology is framed under the National Education Policy (N.E.P. 2022) to prepare its students for society.
2. Each program vividly elaborates its nature and promises the outcomes to be accomplished by studying the courses.
3. 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.
4. Being a fast, economically developing country with depleting natural resources, acute shortage of energy, natural disasters, and many environmental hazards.
5. 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 in Geology.
6. It is an exciting course with both fundamental and applied utility.

PROGRAM LEARNING OUTCOMES

The broad aims of bachelor's degree programme in Geology are:

(i) To help students build up a progressive and successful career in Geology
(ii) To enrich students' knowledge and train them in the pure and applied geological sciences
(iii) To provide an updated education
(iv) To impart more field-oriented knowledge
(v) To inculcate a sense of scientific responsibilities and social and environmental awareness
(vi) To inculcate values and knowledge
(vii) To make them well-being responsible citizen
(viii) To encourage critical thinking with skills of employability
(ix) To introduce the concepts of application and research in Geology
(x) Create a sense of preservation and conservation of natural resources
(xi) To prepare students for sustainability and life-long learning
(xii) To inculcate values and knowledge within students that will make them well-being responsible citizens and encourage critical thinking with the skill of employability
(xiii) In short, each program prepares students for sustainability and lifelong learning.

SEMESTER WISE COURSES IN GEOLOGY MAJOR-1 FOR FYUGP **2022 onwards**

Table 7: Semester wise Examination Structure in Discipline Courses:

Semester	Courses		Examination Structure			
	Code	Papers	Credits	Mid Semester Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical/ Viva (F.M.)
I	MJ-1	Earth System Science	4	25	75	---
II	MJ-2	Crystallography & Mineralogy	4	25	75	---
	MJ-3	**Practical-I**	4	---	---	100
III	MJ-4	Structural Geology and Geomorphology	4	25	75	---
	MJ-5	**Practical-II**	4	---	---	100
IV	MJ-6	Elements of Geochemistry and Igneous Petrology	4	25	75	---
	MJ-7	Sedimentary and Metamorphic Petrology	4	25	75	---
	MJ-8	**Practical-III**	4	---	---	100
V	MJ-9	Stratigraphy	4	25	75	---
	MJ-10	Paleontology	4	25	75	---
	MJ-11	**Practical-IV**	4	---	---	100
VI	MJ-12	Economic and Exploration Geology	4	25	75	---
	MJ-13	Hydrogeology and Engineering Geology	4	25	75	---
	MJ-14	Geological Mapping and Image Processing Techniques	4	25	75	---
	MJ-15	**Practical-V**	4	---	---	100
VII	MJ-16	Fossil Fuel Geology	4	25	75	---
	MJ-17	Geotectonics and Applied Structural Geology	4	25	75	---
	MJ-18	Advanced Stratigraphy and Palaeobiology	4	25	75	---
	MJ-19	**Practical-VI**	4	---	---	100
VIII	MJ-20	Advance Crystallography and Descriptive Mineralogy	4	25	75	---
	AMJ-1	Geochemistry and Advance Petrology	4	25	75	---
	AMJ-2	Geomorphology and RS-GIS in Geology	4	25	75	---
	AMJ-3	**Practical-VII**	4	---	---	100
	or RC-1	Research Methodology	4	25	75	---
	RC-2	Project Dissertation/ Research Internship/ Field Work	8	---	---	200
		Total Credit	**92**			

Table 8: Semester wise Course Code and Credit Points for Skill Enhancement Courses:

Semester	Skill Enhancement Courses		Examination Structure			
	Code	Papers	Credits	Mid Semester Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical/ Viva (F.M.)
I	SEC-1	Geomorphology & Geotectonics	3	---	75	---
II	SEC-2	Basics of Geochemistry	3	---	75	---
III	SEC-3	Elementary Computer Application Softwares	3	---	75	---
		Total Credit	**9**			

Table 9: Semester wise Course Code and Credit Points for Minor Courses:

Semester	Minor Courses		Examination Structure			
	Code	Papers	Credits	Mid Semester Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical/ Viva (F.M.)
I	MN-1A	Introductory Geology	4	15	60	25
III	MN-1B	Essentials of Geology, Rocks & Minerals	4	15	60	25
V	MN-1C	Earth Resources	4	15	60	25
VII	MN-1D	Fossils & Their Applications	4	15	60	25
		Total Credit	**16**			

INSTRUCTION TO QUESTION SETTER

SEMESTER INTERNAL EXAMINATION (SIE):

There will be Only One Semester Internal Examination in Major, Minor and Research Courses, which will be organized at college/institution level. However, Only One End semester evaluation in other courses will be done either at College/ Institution or University level depending upon the nature of course in the curriculum.

A. (SIE 10+5=15 marks):

There will be two group of questions. **Question No.1 will be very short answer type in Group A** consisting of five questions of 1 mark each. **Group B will contain descriptive type** two questions of five marks each, out of which any one to answer.

The Semester Internal Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks, (b) Class Attendance Score (CAS) of 5 marks.

B. (SIE 20+5=25 marks):

There will be two group of questions. **Group A is compulsory** which will contain two questions. **Question No.1 will be very short answer type** consisting of five questions of 1 mark each. **Question No.2 will be short answer type** of 5 marks. **Group B will contain descriptive type** two questions of ten marks each, out of which any one to answer.

The Semester Internal Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 20 Marks, (b) Class Attendance Score (CAS) of 5 marks.

Conversion of Attendance into score may be as follows:

Attendance Upto 45%, 1mark; 45<Attd.<55, 2 marks; 55<Attd.<65, 3 marks; 65<Attd.<75, 4 marks; 75<Attd, 5 marks.

END SEMESTER UNIVERSITY EXAMINATION (ESE):

A. (ESE 60 marks):

There will be two group of questions. **Group A is compulsory** which will contain three questions. **Question No.1 will be very short answer type** consisting of five questions of 1 mark each. **Question No.2 & 3 will be short answer type** of 5 marks. Group B will contain descriptive type five questions of fifteen marks each, out of which any three are to answer.

B. (ESE 75 marks):

There will be two group of questions. **Group A is compulsory** which will contain three questions. **Question No.1 will be very short answer type** consisting of five questions of 1 mark each. **Question No. 2 & 3 will be short answer type** of 5 marks. Group B will contain descriptive type six questions of fifteen marks each, out of which any four are to answer.

C. (ESE 100 marks):

There will be two group of questions. **Group A is compulsory** which will contain three questions. **Question No.1 will be very short answer type** consisting of ten questions of 1 mark each. **Question No. 2 & 3 will be short answer type** of 5 marks. Group B will contain descriptive type six questions of twenty marks each, out of which any four are to answer.

FORMAT OF QUESTION PAPER FOR SEMESTER INTERNAL EXAMINATION

Question format for **10 Marks**:

Subject/ Code

F.M. =10 **Time**=1Hr. Exam Year

General Instructions:

i. **Group A** carries very short answer type compulsory questions.
ii. **Answer 1 out of 2** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....

Group B

2. ..... [5]
3. ..... [5]

Note: There may be subdivisions in each question asked in Theory Examination.

Question format for **20 Marks**:

Subject/ Code

F.M. =20 **Time**=1Hr. Exam Year

General Instructions:

i. **Group A** carries very short answer type compulsory questions.
ii. **Answer 1 out of 2** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....
2. ..... [5]

Group B

3. ..... [10]
4. ..... [10]

Note: There may be subdivisions in each question asked in Theory Examination.

FORMAT OF QUESTION PAPER FOR END SEMESTER UNIVERSITY EXAMINATION

Question format for **50 Marks**:

Subject/ Code

F.M. =50 **Time**=3Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer type **compulsory** questions.
ii. **Answer 3 out of 5** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....

Group B

2. ..... [15]
3. ..... [15]
4. ..... [15]
5. ..... [15]
6. ..... [15]

Note: There may be subdivisions in each question asked in Theory Examination.

Question format for **60 Marks**:

Subject/ Code

F.M. =60 **Time**=3Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer type **compulsory** questions.
ii. **Answer 3 out of 5** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....
2. ..... [5]
3. ..... [5]

Group B

4. ..... [15]
5. ..... [15]
6. ..... [15]
7. ..... [15]
8. ..... [15]

Note: There may be subdivisions in each question asked in Theory Examination.

Question format for **75 Marks**:

Subject/ Code

F.M. = 75 **Time**=3Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer type **compulsory** questions.
ii. **Answer 4 out of 6** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....
2. ..... [5]
3. ..... [5]

Group B

4. ..... [15]
5. ..... [15]
6. ..... [15]
7. ..... [15]
8. ..... [15]
9. ..... [15]

Note: There may be subdivisions in each question asked in Theory Examination.

Question format for **100 Marks**:

Subject/ Code

F.M. = 100 **Time**=3Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer type **compulsory** questions.
ii. **Answer 4 out of 6** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [10x1=10]
   i. ..... vi. .....
   ii. ..... vii. .....
   iii. ..... viii. .....
   iv. ..... ix. .....
   v. ..... x .....
2. ..... [5]
3. ..... [5]

Group B

4. ..... [20]
5. ..... [20]
6. ..... [20]
7. ..... [20]
8. ..... [20]
9. ..... [20]

Note: There may be subdivisions in each question asked in Theory Examination.

SEMESTER I

I. MAJOR COURSE –MJ 1:
EARTH SYSTEM SCIENCE

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Learning Objectives
To provide a fundamental understanding of the Earth in the solar system along with its origin, evolution, and different components; to understand the potential fields associated with Earth; the evolution of life through geological time scale.

Course Learning Outcomes
After the completion of the course, the students will be able to:
Acquire a fundamental understanding of the Earth and its components, thorough an understanding of materials and processes of the Earth, and apply the knowledge of earth science to address societal issues.

Unit 1:
Earth as a planet: Holistic understanding of dynamic planet 'Earth' through Geology. Introduction to various branches of Earth Sciences. General Characteristics and Origin of the Universe, Solar System, and Planets. The terrestrial and Jovian planets. Meteorites and Asteroids. Earth in the solar system - Origin, size, shape, mass, density, rotational and revolution parameters, and age.

Unit 2:
Interior of Earth: Internal Structure of the early Earth's magnetic field: Convection in Earth's core and production of its magnetic field.

Unit 3:
Plate Tectonics: Concept of plate tectonics, sea-floor spreading and continental drift, Geodynamic elements of Earth-Mid Oceanic Ridges, trenches, transform faults and island arcs origin of oceans, continents, mountains and rift valleys, Earthquake and earthquake belts, Volcanoes- types, products and their distribution.

Unit 4:
Hydrosphere and Atmosphere: Introduction to hydrosphere and atmosphere; Oceanic current system and effect of Coriolis force; Wave erosion and beach processes; Atmospheric circulation; Earth's heat budget.

Soils: processes of formation, soil profile and soil types.

Unit 5:
Understanding the past from stratigraphic records, Stratigraphy: Introduction and scope; Geological Time Scale, Standard stratigraphic time scale Introduction to geochronological methods and their application in geological studies; Laws of superposition and faunal succession; Concepts of uniformitarianism.

Suggested Readings:

1. Duff, P. M. D., & Duff, D. (Eds.). (1993). Holmes' principles of physical geology. Taylor & Francis.
2. Emiliani, C. (1992). Planet Earth: cosmology, geology, and the Evolution of Life and Environment. Cambridge University Press.
3. Gross, M. G. (1977). Oceanography: A view of the Earth.
4. Krishnan, M. S. (1982). Geology of India and Burma, C.B.S. Publishers, Delhi.
5. Kumar, R. (1991). Fundamentals of Historical Geology and Stratigraphy of India. New Age International Publishers.
6. Wadia, D.N. (1919). Geology of India, Macmillan publishers.
7. Holmes, A. (1945). Principles of Physical Geology. Thomas Nelson and Sons Ltd., London, Edinburgh, Paris, Melbourne, Toronto and New York.

II. SKILL ENHANCEMENT COURSE- SEC 1: GEOMORPHOLOGY & GEOTECTONICS

Marks: 75 (ESE: 3Hrs) = 75	Pass Marks: Th (ESE) = 30

(Credits: Theory-03) **45 Hours**

Course Objectives:
To provide a fundamental understanding of various landforms formed by different agents, exogenic and endogenic forces, earths and its spheres along with generation and movement of several plates.

Learning Objectives:
After the completion of the course, the students will be able to:
Have a good understanding of the earth and its spheres, various forces operating on it and geological work of various agents and concept of plate tectonics.

Course Contents:

Unit-1: Basic principles of Geomorphology, geomorphological cycles, weathering and erosion; Geomorphic mapping- tools and techniques.

Unit-2: Epigene/exogenic processes: degradation and aggradation. Hypogene/endogenic processes; Diastrophism and volcanism, Extraterrestrial processes; Geological work of wind, glacier, river, underground water and ocean.

Unit-3: Earth as a dynamic system. Elementary idea of continental drift, sea-floor spreading and mid-oceanic ridges. Paleomagnetism and its application.

Unit-4: Plate Tectonics: the concept, plate margins, orogeny, deep sea trenches, island arcs and volcanic arcs.

Unit-5: Earth and its spheres: atmosphere, hydrosphere, lithosphere, biosphere & Man; Earth Material.

Books Recommended:

1. Allen, P., 1997. Earth Surface Processes. Blackwell
2. Bloom, A.L., 1998. Geomorphology: A systematic Analysis of Late Cenozoic Landforms (3rd Edition).
3. Pearson Education, Inc.
4. Keary, P. and Vine, F.J., 1997. Global Tectonics. Blackwell and crustal evolution. Butterworth-Heinemann.
5. Kale, V.S. and Gupta, A., 2001. Introduction to Geomorphology. Orient Longman Ltd.
6. Moores, E and Twiss. R.J., 1995. Tectonics. Freeman.
7. Patwardhan, A. M., 1999. The Dynamic Earth System. Prentice Hall.
8. Summerfied, M.A., 2000. Geomorphology and Global tectonic. Springer Verlag.
9. Valdia, K.S., 1988. Dynamic Himalaya. Universities Press, Hyderabad.
10. WD Thornbury, 2002. Principles of Geomorphology. CBS Publ. New Delhi.
11. Verma, V.K., 1986. Geomorphology Earth surface processes and form. McGraw Hill.
12. Chorley, R. J., 1984. Geomorphology. Methuen.
13. Selby, M.J., 1996. Earths Changing Surface. Oxford University Press UK.
14. Thornbury W. D., 1997. Principles of Geomorphology Wiley Eastern Ltd., New Delhi.
15. Valdiya, K. S., 1987. Environmental Geology - Indian Context. Tata McGraw Hill New Delhi.
16. Keller, E. A., 2000. Environmental Geology. Shales E. Merril Publishing Co., Columbus, Ohio.
17. Montgomery, C., 1984. Environmental Geology. John Wiley and Sons, London.
18. Bird, Eric, 2000. Coastal Geomorphology: An Introduction. John Wiley & Sons, Ltd. Singapore.
19. Liu, B.C., 1981. Earthquake Risk and Damage, Westview.

SEMESTER II

I. MAJOR COURSE- MJ 2:
CRYSTALLOGRAPHY & MINERALOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Learning Objectives

To provide a fundamental understanding of crystal system, symmetry and chemistry to understand the importance of minerals in our daily life; to provide comprehensive knowledge of the structure of silicates and different groups of minerals.

Course Learning Outcomes

After the completion of the course, students will be able to:

Have a good understanding of the different symmetry elements, a comprehensive understanding of the importance and application of minerals/mineral groups, knowledge of the Structure and composition, the economic importance of minerals and building an overall knowledge in geology, knowledge of application and usage of minerals in industries.

Unit 1:

Crystallography: Elementary ideas about crystal morphology concerning internal structures, Crystal parameters and indices, Crystal symmetry and Classification of crystals into six systems (Normal Class) and 32-point groups.

Unit 2:

Crystal symmetry and projections, Elements of crystal chemistry and aspects of crystal structures, Stereographic projections of symmetry elements and forms.

Unit 3:

Rock-forming minerals: Minerals-definition and Classification, physical and chemical properties, Composition of common rock-forming minerals, Silicate and non-silicate structures; C.C.P. and H.C.P. structures.

Unit 4:

Properties of light and optical microscopy, Nature of light and principles of optical mineralogy
Introduction to the petrological microscope and identification of common rock-forming minerals.

Unit 5:

Description of physical, chemical and optical properties of the following mineral groups: Olivine, Pyroxene, Amphibole, Quartz, and Feldspar.

Suggested Readings:

1. Klein, C., Dutrow, B., Dwight, J., & Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.
2. Kerr, P. F. (1959). Optical Mineralogy. McGraw-Hill.
3. Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.
4. Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.
5. Read, H.H. (1988). Elements of Mineralogy. Surjeet Publication.

II. MAJOR COURSE- MJ 3:
PRACTICALS-I:

Marks: Pr (ESE: 3Hrs) =100	Pass Marks: Pr (ESE) = 40

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practical:

1. Observation and documentation of the symmetry of crystals
2. Study of physical properties of minerals in hand specimen: Silicates: Olivine, Garnet, Andalusite, Sillimanite, Kyanite, Staurolite, Beryl, Tourmaline, Augite, Actinolite, Tremolite, Hornblende, Serpentine, Talc, Muscovite, Biotite, Phlogopite, Quartz, Orthoclase, Plagioclase, Microcline, Nepheline, Sodalite, Zeolite, Quartz varieties: Chert, Flint, Chalcedony, Agate, Jasper, Amethyst, Rose quartz, Smoky quartz, Rock crystal.
3. Native Metals/non-metals, Sulfides, Oxides- Copper, Sulfur, Graphite, Pyrite, Corundum, Magnetite Hydroxides, Halides, Carbonates, Sulfates, Phosphates: Psilomelane, Fluorite, Calcite, Malachite, Gypsum, Apatite.
4. Study of some essential silicate minerals under an optical microscope and their characteristic properties

Fieldwork:

1. Geological mapping of one-week duration in a geologically complex area and Field Work Report based on it.

Reference Books:

1. Laboratory Manual of Geology A K Sen (Modern Book Agency Pvt. Ltd. Calcutta)
2. Singh, RP. (1965). Structural Geology: A Practical Approach, Ganga Kaveri Publication House, Varanasi. 133p.
3. Bennison, G.M. (1990). An Introduction to Geological Structure and Maps, Fifth Edition, Edward Arnold. London. 5th Edition, 67p.

III. SKILL ENHANCEMENT COURSE- SEC 2:
BASICS OF GEOCHEMISTRY

Marks: 75 (ESE: 3Hrs) = 75	Pass Marks: Th (ESE) = 30

(Credits: Theory-03) **45 Hours**

Course Objectives:
To provide a fundamental understanding of crystal chemistry, elements, thermodynamics, meteorites, and geochemical cycles.

Learning Objectives:
After the completion of the course, the students will be able to:
Have a good understanding of various aspects of elements and crystals, geochemical concepts of planets, thermodynamics

Course Contents:

Unit-1: Introduction to geochemistry: basic knowledge about crystal chemistry. Types of chemical bonds, coordination number; Colloids in geological systems, ion exchanges and geological evidence for earlier colloids; Elementary idea of Periodic Table.

Unit-2: Cosmic abundance of elements; Composition of the planets and meteorites; Geochemical evolution of the earth and geochemical cycles;

Unit-3: Gold Schmidt's geochemical classification of elements; Distribution of major, minor and trace elements in igneous, metamorphic and sedimentary rocks.

Unit-4: Elements of geochemical thermodynamics; Isomorphism and polymorphism; Isotope geochemistry.

Unit 5: Geochemistry and principles of evolution of hydrosphere, biosphere and atmosphere. Geochemical cycle and principles of geochemical prospecting.

Books Recommended:

1. Hoefs, J., 1980. Stable Isotope Geochemistry. Springer-Verlag.
2. Klein, C. and Hurlbut, C.S., 1993. Manual of Mineralogy. John Viley and Sons, New York.
3. Krauskopf, K.B., 1967. Introduction to Geochemistry. McGraw Hill.
4. Mason, B. and Moore, C.B., 1991. Introduction to Geochemistry. Wiley Eastern.
5. Rollinson, H.R., 1993. Using geochemical data: Evaluation, Presentation, and Interpretation. Longman

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SEMESTER III

I. MAJOR COURSE- MJ 4:
STRUCTURAL GEOLOGY & GEOMORPHOLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Learning Objectives:
To understand the structural elements and steps in structural analysis, stress-strain relationships, deformation patterns, and strain distribution in the crust, a basic understanding of the deformation and structures in different tectonic settings.
To introduce comprehensive knowledge of the fundamentals of Geomorphology and Earth surface processes and their interactions between exogenic and endogenic forces; to learn about the various landforms by different agents.

Course Learning Outcomes:
After completion of the course, the student will be able to develop the following:
Understanding the geometry, kinematics and deformation dynamics in Earth's crust. Knowledge about the instability of the lithosphere produced by complex plate tectonic movements and deformation patterns and structures developed during deformation. Also, identify the linear and planar fabrics (L-S Tectonites) and their relation to major geological structures.
Knowledge of the formation of various landforms, the interplay of climate, tectonics and denudation on the landscapes, the interaction between exogenic and endogenic processes; applying the knowledge of geomorphology to land use and land cover planning.

Unit 1:
Structure and Topography, Effects of topography on structural features, Topographic and structural maps; Importance of representative factors of the map, Stress and strain in rocks, Concept of rock deformation: Stress and Strain in rocks, Strain ellipses of different types and their geological significance. Planar and linear structures; Concept of dip and strike; Outcrop patterns of different structures.

Unit 2:
Folds: Fold morphology; Geometric and genetic Classification of folds; Introduction to the mechanics of folding: Buckling, Bending, Flexural slip and flow folding, Fractures and faults: Geometric and genetic Classification of fractures and faults, Effects of faulting on the outcrops, Geologic/geomorphic criteria for recognition of faults and fault plane solutions.

Unit 3:
Foliation and lineation: Description and Origin of foliations: axial plane cleavage and its tectonic significance Description and Origin of lineation and relationship with the significant structures.

Unit 4:
Introduction to Geomorphology, Endogenic and Exogenic processes, Endogenic- Exogenic interactions, Rates of uplift and denudation, Tectonics and drainage development, Sea-level change, and Long-term landscape development.
Geoid, Topography, Hypsometry, Global Hypsometry; Major Morphological features Large Scale Topography - Ocean basins, large scale mountain ranges (with emphasis on the Himalayas).

Unit 5:
Surficial Processes and geomorphology: Weathering and associated landforms, Glacial, Periglacial processes and landforms, Fluvial processes and landforms, Aeolian Processes and landforms, Coastal Processes and landforms, Landforms associated with igneous activities, Overview of Indian Geomorphology.

Suggested Readings:

1. Davis, G. R. (1984). Structural Geology of Rocks and Region. John Wiley
2. Billings, M. P. (1987). Structural Geology, 4th Edition, Prentice-Hall.
3. Park, R. G. (2004). Foundations of Structural Geology. Chapman & Hall.
4. Pollard, D. D. (2005). Fundamental of Structural Geology. Cambridge University Press.
5. Ragan, D. M. (2009). Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical)
6. Lahee, F. H. (1962). Field Geology. McGraw Hill
7. Robert S. Anderson and Suzzane P. Anderson (2010). Geomorphology - The Mechanics and Chemistry of Landscapes. Cambridge University Press.
8. M.A. Summerfield (1991). Global Geomorphology. Wiley & Sons

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II. MAJOR COURSE- MJ 5:
PRACTICALS-II:

Marks: Pr (ESE: 3Hrs) =100	**Pass Marks: Pr (ESE) = 40**

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:

1. The basic idea of topographic contours, Topographic sheets of various scales
2. Introduction to Geological Maps: Lithological and Structural Maps
3. Structural contouring and 3-point problems of dip and strike
4. Drawing profile sections and interpreting geological maps of different complexities. Exercises of stereographic projections of mesoscopic structural data (planar, linear, folded etc.)
5. Reading topographic maps, Concept of scale, Preparation of a topographic profile, Preparation of longitudinal profile of a river; Preparing Hack Profile; Calculating Stream length gradient index, Morphometry of a drainage basin, and calculating different morphometric parameters. Preparation of the geomorphic map, Interpretation of geomorphic processes from the geomorphology of the area.

Reference Books:

1. Laboratory Manual of Geology A.K. Sen (Modern Book Agency Pvt. Ltd. Calcutta)
2. Singh, RP. (1965). Structural Geology: A Practical Approach, Ganga Kaveri Publication House, Varanasi. 133p.
3. Bennison, G.M. (1990). An Introduction to Geological Structure and Maps, Fifth Edition, Edward Arnold. London. 5th Edition, 67p.

III. SKILL ENHANCEMENT COURSE- SEC 3:
ELEMENTARY COMPUTER APPLICATION SOFTWARES

Marks: 75 (ESE: 3Hrs) = 75	Pass Marks: Th (ESE) = 30

A Common Syllabus for FYUGP (Credits: Theory-03) **45 Hours**

Instruction to Question Setter for
End Semester Examination (ESE):
*There will be **objective type test** consisting of **Seventy-five questions of 1 mark each**. Students are required to mark their answer on **OMR Sheet** provided by the University.*

Course Objectives:

The objective of the course is to generate qualified manpower in the area of Information Technology (IT) and Graphic designing which will enable such person to work seamlessly at any Offices, whether Govt. or Private or for future entrepreneurs in the field of IT.

A. INTRODUCTION TO COMPUTER SYSTEM

1. Basic Concept of Computer: What is Computer, Applications of Computer, Types of computer, Components of Computer System, Central Processing Unit (CPU) **(3 Lecture)**

2. Concepts of Hardware: Input Devices, Output Devices, Computer Memory, Types of Memory, processing Concept of Computer **(4 Lecture)**

3. Operating system: What is an Operating System, Operating System Examples, Functions of Operating System(Basic), Introduction to Windows 11, Working on Windows 11 environment, Installation of Application Software, My Computer, Control Panel, searching techniques in windows environment, Basic of setting **(6 Hours)**

4. Concept of Software: What is Software, Types of Software, Computer Software- Relationship between Hardware and Software, System Software, Application Software, some high level languages **(4 Hours)**

5. Internet & its uses: Basic of Computer networks; LAN, WAN, MAN, Concept of Internet, Applications of Internet; connecting to internet, what is ISP, World Wide Web, Web Browsing software's, Search Engines, URL, Domain name, IP Address, using e-governance website, Basics of electronic mail, getting an email account, Sending and receiving emails. **(6 Hours)**

B. MICROSOFT OFFICE 2016 AND LATEST VERSIONS

6. Microsoft Word: Word processing concepts, Creation of Documents, Formatting of Documents, Formatting of Text, Different tabs of word 2016 environment, Formatting Page, Navigation of Page, Table handling, Header and footer, Page Numbering, Page Setup, Find and Replace, Printing the documents **(7 Hours)**

7. Microsoft Excel (Spreadsheet): Spreadsheet Concepts, Creating, Saving and Editing a Workbook, Inserting, Deleting Work Sheets, Formatting worksheet, Excel Formula, Concept of charts and Applications, Pivot table, goal seek, Data filter, data sorting and scenario manager, printing the spreadsheet **(6 Hours)**

8. Microsoft Power Point (Presentation Package): Concept and Uses of presentation package, Creating, Opening and Saving Presentations, working in different views in Power point, Animation, slide show, Master Slides, Creating photo album, Rehearse timing and record narration **(5 Hours)**

9. Digital Education: What is digital education, Advantages of digital Education, Concept of e-learning, Technologies used in e learning **(4 Hours)**

Reference Books

1. Nishit Mathur, Fundamentals of Computer, APH publishing corporation (2010)
2. Neeraj Singh, Computer Fundamentals (Basic Computer), T Balaji, (2021)
3. Joan Preppernau, Microsoft Power Point 2016 step by step, Microsoft press (2015)
4. Douglas E Corner, The Internet Book 4th Edition, prentice –Hall (2009)
5. Steven Welkler, Office 2016 for beginners, Create Space Independent Publishing Platform (2016)
6. Wallace Wang, Microsoft Office 2019, Wiley (January 2018)
7. Noble Powell, Windows 11 User Guide For Beginners and Seniors, ASIN, (October 2021)

SEMESTER IV

I. MAJOR COURSE- MJ 6:
ELEMENTS OF GEOCHEMISTRY AND IGNEOUS PETROLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Learning Objectives:
To provide comprehensive knowledge on how chemical principles are used to explain the mechanisms that control the large geological systems such as the Earth's mantle, crust, ocean and atmosphere, and the formation of the solar system; understanding of the qualitative and quantitative composition of planet Earth and solar system material; knowledge on geological processes and their geochemical signatures; understanding of geochemical behaviour of elements and isotopes and their applications in addressing the evolution of planet Earth through time including the origin of life and long term climate variability.
To develop a fundamental understanding of magmas, their origin, differentiation histories, Importance of igneous rocks in continental growth and formation of ore deposits, crystallisation and emplacement history of magmas through a study of textures and structures, magmatism through time in different geodynamic settings.

Course Learning Outcomes:
After completion of the course, the student will be able to develop the following:
Understand fundamental processes in Earth science in a geochemical context; Quantify the geological processes through trace element modelling; Understand the human influence and impacts on surface processes; Apply basic geochemical techniques to explain, interpret and predict common processes in Earth science; Develop the ability to explain, interpret and predict common processes in Earth sciences in a geochemical context; Acquire the ability to solve applied quantitative problems in Earth Sciences using geochemical principles. Understanding of magmas, their origin, and differentiation histories; Importance of igneous rocks in continental growth and formation of ore deposits, crystallisation and emplacement history of magmas; ability to understand magmatism through time in different geodynamic settings, crust-mantle system; gain knowledge of the economic potential of igneous rocks.

Unit 1: Concepts of geochemistry: Introduction to properties of elements: The periodic table. Chemical bonding, states of matter and atomic environment of elements. Geochemical Classification of elements, Layered Structure of Earth and geochemistry: Composition of different Earth reservoirs and the nuclides and radioactivity, conservation of mass, isotopic and elemental fractionation, Concept of radiogenic isotopes in geochronology and isotopic tracers, Element transport, Advection and diffusion. Chromatography, Aqueous geochemistry- fundamental concepts and speciation in solutions, Eh, pH relations.

Unit 2: Geochemistry of solid Earth: The solid Earth–geochemical variability of magma and its products, The Earth in the solar system, the formation of the solar system, composition of the bulk silicate earth. Meteorite, Cosmic abundance of elements: Distribution of elements in the solar system and Earth, Chemical differentiation and composition of the Earth, General concepts about geochemical cycles and mass balance Properties of elements. Geochemical behaviour of major elements Mass conservation of elements and isotopic fractionation.

Unit 3: Concepts of Igneous petrology: Introduction to petrology: Heat flow, geothermal gradients through time, origin and nature of magma, Bowen's Reaction Series and Magmatic Differentiation. Forms: Classification of igneous rocks. Textures and structures of igneous rocks, mode of occurrence of Igneous rocks.

Unit 4: Phase diagrams and petrogenesis: Binary Phase diagrams in understanding crystal-melt equilibrium – An-Ab, Or-Ab, Di-An Magma generation in crust and mantle, their emplacement and evolution
Magmatism in different tectonic settings: Magmatism in the oceanic domains (MORB, O.I.B.)
Magmatism along the plate margins (Island arcs/continental arcs).

Unit 5: Petrogenesis of Igneous rocks: Petrogenesis of Felsic and Mafic igneous rocks
Komatiites, Granitoides, Basalt, Gabbros, Alkaline rocks, Kimberlites and Lamproites.

Suggested Readings:

1. Mason, B. (1986). Principles of Geochemistry. 3rd Edition, Wiley New York.
2. Rollinson, H. (2007). Using geochemical data – evaluation, presentation and Interpretation. 2nd Edition. Publisher Longman Scientific & Technical.
3. Walther, J. V. (2009). Essentials of geochemistry. Jones & Bartlett Publishers.
4. Albarède, F. (2003). Geochemistry: an introduction. Cambridge University Press.
5. Faure, Gunter and Teresa M. Mensing (2004). Isotopes: Principles and Applications, Wiley India Pvt.
6. Philpotts, A. & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
7. Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
8. Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, Interpretation. Routledge.
9. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
10. McBirney, A. R. (1984). Igneous Petrology. San Francisco (Freeman, Cooper & Company) and Oxford (Oxford Univ. Press),
11. Best, M.G. (2001). Igneous and Metamorphic Petrology, K.G. Cox, J.D. Bell. (1979). The Interpretation of Igneous Rocks. Springer/Chapman & Hall.
12. Bose, M.K. (1997). Igneous Petrology.
13. Tyrrell, G.W. (1926). Principles of Petrology. Springer.

II. MAJOR COURSE- MJ 7:
SEDIMENTARY AND METAMORPHIC PETROLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Learning Objectives:
To understand the fundamentals of sedimentary processes and their products, formation and filling history of sedimentary basins in different tectonic regions, a comprehensive understanding of both clastic and chemical sedimentation processes, comprehensive understanding of varieties of sedimentary rocks. To understand the thermal history of the crust-mantle system and tectonics, factors controlling the metamorphism and metamorphism as a chemical system, kinetics of reactions, metamorphic facies, grade, and comprehensive details of various metamorphic rocks.

Course Learning Outcomes:
After completion of the course, the student will be able to develop:
To describe scales of sedimentary grain size measurement and transportation history or depositional environment; To understand the texture and structure of clastic sedimentary rocks; procedure and importance of paleocurrent analysis; To comprehend the Concept of sedimentary environment and description of processes and products of different sedimentary environments. To understand the nature of metamorphic rocks and the factors controlling the metamorphism; Knowledge of phase rule as an essential tool in the study of the metamorphic assemblages; Deduce the pressure-temperature-time paths of metamorphism and its link to tectonics; Understand the spatial link between the metamorphism, fluid flow, and mineralisation.

Unit 1: Origin of sediments: Weathering and sedimentary flux: Physical and chemical weathering, soils and paleosols, Sediment granulometry: Grain size scale, particle size distribution, Environmental connotation; particle shape and fabric, Sedimentary textures, structures and environment: Fluid flow, sediment transport and sedimentary structures: Types of fluids, Laminar vs turbulent flow, Particle entrainment, transport and deposition. Paleocurrent analysis- Paleocurrents for different sedimentary environments, Sedimentary Structure- Primary and syn-sedimentary structures.

Unit 2: Varieties of sedimentary rocks: Siliciclastic rocks: Conglomerates, sandstones, mudrocks. Carbonate rocks, controls of carbonate deposition, Components and Classification of Sandstones, limestone, dolomite and dolomitisation Diagenesis: Concepts of diagenesis, Stages of diagenesis, Compaction and cementation.

Unit 3: Metamorphism: controls and types. Definition of metamorphism. Factors controlling metamorphism, Types of metamorphism - contact, regional, fault zone metamorphism, impact metamorphism, Metasomatism and role of fluids in metamorphism, Metamorphism and Tectonism, Relationship between metamorphism and deformation, Metamorphic mineral reactions (prograde and retrograde).

Unit 4: Metamorphic facies and grades, Metamorphic zones and isograd, Index minerals, Mineralogical phase rule of the closed and open system, structure and textures of metamorphic rocks, and Concepts of Chemo-graphic projections.

Unit 5: Migmatites and their Origin, Metamorphic rock associations- Schists, Gneisses, Khondalite, Charnockite, Blue schists and Eclogites.

Suggested Readings:

1. Prothero, D. R., & Schwab, F. (2004). Sedimentary geology. Macmillan.
2. Tucker, M. E. (2006). Sedimentary Petrology, Blackwell Publishing.
3. Collinson, J. D. & Thompson, D. B. (1988) Sedimentary structures, Unwin- Hyman, London.
4. Nichols, G. (2009). Sedimentology and Stratigraphy Second Edition. Wiley Blackwell
5. Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
6. Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
7. Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, Interpretation. Routledge.
8. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
9. Yardley, B. W., & Yardley, B.W.D. (1989). An introduction to metamorphic petrology. Longman Earth Science Series.

III. MAJOR COURSE- MJ 8:
PRACTICALS-III:

Marks: Pr (ESE: 3Hrs) =100	Pass Marks: Pr (ESE) = 40

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:

1. Types of geochemical data analysis and Interpretation of typical geochemical plots
2. Geochemical analysis of geological materials
3. Geochemical variation diagrams and their interpretations
4. Study of important igneous rocks in hand specimens and thin sections
5. Q.A.P. and Q.A.P.F. Diagrams.
6. Megascopic study of sedimentary structures, Particle size distribution and statistical treatment
7. Paleocurrent analysis, Petrography of clastic and non-clastic rocks through hand specimens and thin sections
8. Megascopic and microscopic study (textural and mineralogical) of different metamorphic rocks
9. Graphic plots for petrochemistry and Interpretation of assemblages: A.C.F., A.K.F. and A.F.M. diagrams.

Fieldwork:

1. Geological mapping of one-week duration in a geologically complex area and Field Work Report based on it.

Reference Books:

1. Laboratory Manual of Geology A K Sen (Modern Book Agency Pvt. Ltd. Calcutta)
2. Singh, RP. (1965). Structural Geology: A Practical Approach, Ganga Kaveri Publication House, Varanasi. 133p.
3. Bennison, G.M. (1990). An Introduction to Geological Structure and Maps, Fifth Edition, Edward Arnold. London. 5th Edition, 67p.

SEMESTER V

I. MAJOR COURSE- MJ 9: STRATIGRAPHY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:
To provide a basic understanding of rock superposition of beds through time and their relative age; understanding of stratigraphy to apply in an exploration of energy and mineral resources, codes of stratigraphy and how they have been developed; To learn about precisely stratigraphy sequences through seismic, magnetic, chemical, and absolute dating methods.

Course Learning Outcomes:
After the completion of the course, the student will be able to:
Understand fundamentals of stratigraphic principles, different types of stratigraphic units; evolution of life through time; the spatial and temporal relationship between litho-units and their correlation with similar units in other continents; Better understanding of stratigraphy leads to the identification of potential zones of mineral and energy resources; Application of stratigraphy to characterise the evolution of life through time and mass extinctions.

Unit 1: Principles of stratigraphy, Introduction to lithostratigraphy, biostratigraphy, chrono-stratigraphy, seismic stratigraphy, chemo-stratigraphy, Magneto-stratigraphy; International Stratigraphic Code-development of standardised stratigraphic nomenclature. Concepts of Strato types. Global Stratotype Section and Point (G.S.S.P.).

Unit 2: Principles of stratigraphic analysis and Physiographic and tectonic subdivisions of India, Walther's Law of Facies, Concept of paleogeographic reconstruction; Sequence stratigraphy and their subdivisions with Indian examples. Introduction to India's physiographic and tectonic subdivisions, Introduction to Indian Shield.

Unit 3: Precambrian-Stratigraphy of India: Precambrian geology of Singhbhum and Dharwar; Introduction to Proterozoic basins of India; Geology of Vindhyan and Cuddapah basins of India.

Unit 4: Phanerozoic Stratigraphy of India: Geology, Structure and hydrocarbon potential of Gondwana Basins.
Mesozoic stratigraphy of India:

a. Triassic successions of Spiti,
b. Jurassic of Kutch,
c. Cretaceous successions of Cauvery basins

Cenozoic stratigraphy of India:

a. Siwalik successions
b. b. Assam basins.

Stratigraphy and Structure of Krishna-Godavari Basin, Cauvery Basin, Bombay offshore Basin, Kutch and Saurashtra Basins and their potential for hydrocarbon exploration.

Unit 5: Volcanic provinces of India and Stratigraphic boundaries

a. Deccan, b. Rajmahal,

Important Stratigraphic Boundaries in India:

a. Precambrian-Cambrian boundary, b. Permian-Triassic boundary, and c. Cretaceous-Tertiary boundary

Suggested Readings:

1. Krishnan, M.S. (1982). Geology of India and Burma, C.B.S. Publishers, Delhi
2. Doyle, P. & Bennett, M. R. (1996). Unlocking the Stratigraphic Record. John Wiley Ramakrishnan, M. & Vaidyanadhan, R. (2008). Geology of India Volumes 1 & 2, Geological Society of India, Bangalore.
3. Valdiya, K.S. (2010). The making of India, Macmillan India Pvt. Ltd.

II. MAJOR COURSE- MJ 10: PALEONTOLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:
To study the remains of animals and plants (fossils) of the geological past preserved in the rocks and how life forms had responded to climatic and environmental crises.

Course Learning Outcomes:
After the completion of the course, the student will be able to:
Understanding the evolution of life through time; appreciating how fossils provide information on the paleoenvironments; understanding the adaptability of life in different environments, paleoenvironmental crises and mass extinctions; Origin and distribution of fossil fuels.

Unit 1:
Fossilisation and fossil record: Nature and importance of fossil record; Fossilisation processes and modes of preservation.

Unit 2:
Taxonomy and Species concept: Species concept with special reference to palaeontology Theory of organic evolution.

Unit 3:
Invertebrates: Brief Introduction of important fossil groups: morphology and geological history of Trilobites, Brachiopoda, Gastropod, Cephalopoda and Lamellibranchia.

Unit 4:
Vertebrates and other fossils: Evolution of horse and intercontinental migrations. Human evolution. Gondwana Flora Introduction to Ichnology.

Unit 5:
Application of fossils in Stratigraphy: Palynology: Biostratigraphy, Biozones, index fossils, correlation
Fossils and paleoenvironmental analysis, Fossils and paleobiogeography, biogeographic provinces, Paleoecology – fossils as a window to the evolution of the ecosystem, Microfossils, Paleoclimate and Paleogeography.

Suggested Readings

1. Raup, D. M., Stanley, S. M., Freeman, W. H. (1971). Principles of Palaeontology
2. Clarkson, E. N. K. (2012). Invertebrate palaeontology and evolution 4th Edition by Blackwell Publishing.
3. Benton, M. (2009). Vertebrate palaeontology. John Wiley & Sons.
4. Shukla, A. C., & Misra, S. P. (1975). Essentials of palaeobotany. Vikas Publisher
5. Armstrong, H. A., & Brasier, M.D. (2005). Microfossils. Blackwell Publishing.

III. MAJOR COURSE- MJ 11:
PRACTICALS-IV:

Marks: Pr (ESE: 3Hrs) =100	Pass Marks: Pr (ESE) = 40

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:

1. Study of the geological map of India and identification of major stratigraphic units
2. Study of rocks in hand specimens from known Indian stratigraphic horizons
3. Drawing various paleogeographic maps of Precambrian time
4. Study of different Proterozoic supercontinent reconstructions.
5. Study of fossils showing various modes of preservation
6. Study and labelling diagnostic morphological characters, systematic position, stratigraphic position and age of various invertebrate, vertebrate and plant fossils.

Reference Books:

1. Laboratory Manual of Geology A K Sen (Modern Book Agency Pvt. Ltd. Calcutta)
2. Singh, RP. (1965). Structural Geology: A Practical Approach, Ganga Kaveri Publication House, Varanasi. 133p.
3. Bennison, G.M. (1990). An Introduction to Geological Structure and Maps, Fifth Edition, Edward Arnold. London. 5th Edition, 67p.

SEMESTER VI

I. MAJOR COURSE- MJ 12:
ECONOMIC AND EXPLORATION GEOLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:
To develop a good understanding of ore-forming processes in time and space, factors controlling the ore formation, understanding of the role of minerals in the national economy, and the spatial relationship between magnetism, sedimentation, metamorphism and ore formation; To have a sound knowledge of India's mineral wealth. To understand the basic principles of mineral exploration; good knowledge of the different sampling methods; understanding of different exploration strategies, including geological and geochemical mapping.

Course Learning Outcomes:
After the completion of the course, the student will be able to: Understand the various processes involved in the formation of economically important mineral deposits; Build strategies to locate the mineral deposits; good knowledge about the distribution of Indian mineral deposits, national mineral policy as well as the modern method of classifying mineral deposits (U.N.F.C.); Develop skills to face the current challenges in the non-renewable mineral resources. Develop skills and expertise in the exploration of ore deposits and industrial minerals; a good understanding of exploration techniques, including sampling, drilling and evaluation of reserves.

Unit 1: Ores and gangues: Ores, gangue minerals, tenor, grade and lodes, Resources and reserves: definitions; Classification of economic deposits. Structure and texture of ore deposits, Mineral deposits and concepts of Ore formation: Endogenous processes: Magmatic concentration, skarns, greisen, and hydrothermal deposits. Exogenous processes: weathering products and residual deposits, oxidation and supergene enrichment, and placer deposits.

Unit 2: Mineral exploration: Exploration techniques: Geological, Geophysical and Geochemical Explorations techniques.

Unit 3: Metallic and Non-metallic ores: Mode of Occurrence, chemical composition, uses and distribution in India of the following: Metallic deposits: Ores of Iron, Aluminium, Copper, Manganese, Lead and Zinc. Non-metallic deposits: Mica, Asbestos and Limestone. Metallogenic provinces and epochs; An introduction to atomic minerals and gemstones. Introduction to gemstones.

Unit 4: Mineral Resources: Resource reserve definitions, Mineral resources in industries – historical perspective and present. Prospecting and Exploration, Principles of mineral exploration, Prospecting and exploration-conceptualisation, methodology and stages; Sampling and sampling techniques; Geochemical exploration. Evaluation of data: Evaluation of sampling data: Mean, mode, median, standard deviation and variance**,** Drilling, Logging Core & non-core drilling Planning of boreholes and location of boreholes on the ground, Core-logging.

Unit 5: Reserve estimation and Errors: Principles of reserve estimation, density and bulk density, Factors affecting the reliability of reserve estimation, and Reserve estimation based on geometrical models (square, rectangular, triangular and polygon blocks).

Suggested Readings:

1. Guilbert, J.M. and Park Jr., C.F. (1986). The Geology of Ore Deposits. Freeman & Co.
2. Bateman, A.M. and Jensen, M.L. (1990). Economic Mineral Deposits. John Wiley. Evans, A.M. (1993) Ore Geology and Industrial Minerals. Wiley Laurence Robb. (2005) Introduction to ore-forming processes. Wiley.
3. Gokhale, K.V.G.K. and Rao, T.C. (1978). Ore deposits of India their distribution and processing, Tata McGraw Hill, New Delhi.
4. Deb, S. (1980). Industrial minerals and rocks of India. Allied Publishers.
5. Sarkar, S.C. and Gupta, A. (2014). Crustal Evolution and Metallogeny in India. Cambridge Publications.
6. Moon, C.J., Whatley, M.K.G., Evans, A.M. (2006). Introduction to Mineral Exploration, Blackwell Publishing.

II. MAJOR COURSE- MJ 13:
HYDROGEOLOGY AND ENGINEERING GEOLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:
To understand groundwater's nature, occurrence and movement in a geological context; water-bearing properties of formations, aquifer types and aquifer parameters; basic understanding of groundwater exploration and management.
Develop an understanding of the significance of geology in major engineering projects; the necessity of geological inputs in designing large infrastructural projects such as dams, tunnels, roads etc.

Course Learning Outcomes:
After the completion of the course, the students will be able to:
Have a good understanding of the fundamental concepts of hydrogeology, the occurrence of groundwater, water-bearing properties of formations, aquifer types and aquifer parameters; Apply the concepts of groundwater exploration in an integrated way; learn about aquifers and their parameters, groundwater exploration methods, aspects of groundwater chemistry and groundwater management; apply the knowledge gained to address the societal issues related to groundwater resources and its sustainable management in the context of environmental and climate change.
Understand the significance of geology in major engineering projects; Apply geological knowledge to major infrastructure projects; Have a good understanding of the material properties and effect of natural hazards on engineering structures.

Unit 1: Introduction and basic concepts: Scope of hydrogeology and its societal relevance. Hydrologic cycle: precipitation, evapotranspiration, run-off, infiltration and subsurface water movement. Rock properties affecting groundwater, Vertical distribution of subsurface water, Types of an aquifer, aquifer parameters.

Unit 2: Groundwater flows: Darcy's law and validity, Intrinsic permeability and hydraulic conductivity, Laminar and turbulent groundwater flow, Well hydraulics and Groundwater exploration, Basic Concepts (drawdown; specific capacity etc.) Surface-based groundwater exploration methods Introduction to subsurface borehole logging methods.

Unit 3: Groundwater chemistry: Physical and chemical properties of water and water quality, Introduction to methods of interpreting groundwater quality data using standard graphical plots Sea water intrusion in coastal aquifers. Groundwater management: Surface and subsurface water interaction, Groundwater level fluctuations, Basic concepts of water balance studies, issues related to groundwater resources development and management, Rainwater harvesting and artificial groundwater recharge.

Unit 4: Engineering Geology and its Applications, Scope of Engineering Geology; Elementary concepts of rock mechanics - Strength and Elastic properties. Engineering properties and characteristics of soils. Properties of building stones. The basic concept of Rock Quality Designation (R.Q.D.), Rock Structure Rating (R.S.R.), Rock Mass Rating (R.M.R.), and Tunnelling Quality Index (Q).

Unit 5: Dams and reservoirs: Types of Dams: masonry or concrete dams- gravity, arch and buttress. Earth Dams and composite dams. Geological considerations- topography, structure and lithology, Foundation and seepage problems in dams and their treatment. Reservoir: Reservoir problems- seepage and silting, Tunnels: terminology, definition, types- hard rock and soft rock tunnels. Geological considerations- topography, structure and lithology Bridge sites: Terminology, Bridge structure, types. Geology of bridge sites. Stability of rock slopes and cutting in rocks: Classification of slopes- stable and unstable slopes.

Suggested Readings:
1. Todd, D. K. (2006). Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.
2. Davis, S. N. and De Weist, R.J.M. (1966). Hydrogeology, John Wiley & Sons Inc., N.Y.
3. Karanth, K.R. (1987), Groundwater: Assessment, Development and Management, Tata McGraw-Hill Pub. Co. Ltd.
4. Krynin, D.P. and Judd W.R. (1957). Principles of Engineering Geology and Geotechnique, McGraw Hill (C.B.S. Pub).
5. Johnson, R.B. and De Graf, J.V. (1988). Principles of Engineering Geology, John Wiley.
6. Goodman, R.E. (1993). Engineering Geology: Rock in Engineering constructions. John Wiley & Sons, N.Y.
7. Waltham, T. (2009). Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
8. Bell, F.G. (2006). Basic Environmental and Engineering Geology Whittles Publishing.
9. Bell, F.G. (2007). Engineering Geology, Butterworth-Heineman

III. MAJOR COURSE- MJ 14:
GEOLOGICAL MAPPING AND IMAGE PROCESSING TECHNIQUES

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:
The course is intended to familiarise students with outcrops and basic techniques of fieldwork and geological structure mapping by measuring the structural elements (bedding, cleavage, foliation, lineation, pitch, plunge etc.), Providing an understanding of the reading of toposheets and locating themselves in the field; Introduce students to the field geology to identify the different rocks and fabrics; Provide knowledge of lithological mapping techniques; Also students learn to project structural data on the maps and stereo-net.
Fundamentals of Remote sensing and photogeology, digital image processing, usage of G.P.S. and G.I.S. in geology.

Course Learning Outcomes:
Understanding the importance of toposheets and google maps in geological mapping; knowledge of various rock types and their fabrics; Comprehensive knowledge of measuring the fabrics; Projection of the lithological and fabrics data on the topographic maps; Writing the cross-section of studied corridors using the lithological fabric data.
Learn about several advanced remote sensing concepts, sensors and satellites; learn about the Geophysical remote sensing approaches covering potential fields measurement using aerial and satellite missions; Students are exposed to Digital image processing of remotely sensed data and Interpretation. Recent trends in image processing visualisation and digital mapping.

Unit 1: Toposheets: Definition, scale, and reading various components of a toposheet. Geological map definition, various components of a geological map including scale, legend, structures etc. Geological Fieldwork instruments, Use of clinometer compass, Brunton compass, strike and dip measurements.

Unit 2: Basic field measurement techniques: Bedding dip and strike, Reading contours and topography; trend, plunge, Rake/Pitch; Stereo plots of linear and planar structures; identification of rock types in the field; structures and texture of rocks, Sampling and oriented sample and its significance; Geological Mapping of igneous, sedimentary and metamorphic terrains.

Unit 3: Photogeology: Types and acquisition of aerial photograph, scale and resolution, Elements of air photo interpretation. Identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms.

Unit 4: Remote Sensing: Concepts in remote sensing, Sensors and scanners, Satellites and their characteristics, Data formats- Raster and Vector.
Digital Image Processing: Fundamentals of Image processing, Image Correction, Image enhancement, Image classification, F.C.C. and Image Rationing,

Unit 5: G.I.S.: Datum, Coordinate systems and Projection systems, Introduction to D.E.M. analysis; G.I.S. integration and Case studies-Indian Examples
G.P.S.: Concepts of G.P.S. and DGPS, Applications in earth system sciences. Applications in earth system sciences.

Suggested Readings:

1. Clark, G.B. (1967). Elements of Mining. 3rd Ed. John Wiley & Sons.
2. Arogyaswami, R.P.N. (1996). Courses in Mining Geology. 4th Ed. Oxford-IBH.
3. Demers, M.N. (1997). Fundamentals of Geographic Information System, John Wiley & Sons. Inc.
4. Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J. (2001). G.P.S.: Theory & Practice, Springer Wien New York.
5. Jensen, J.R. (1996). Introductory Digital Image Processing: A Remote Sensing Perspective, Springer- Verlag.
6. Lillesand, T. M. & Kiefer, R.W. (2007). Remote Sensing and Image Interpretation, Wiley.
7. Richards, J.A. and Jia, X., (1999). Remote Sensing Digital Image Analysis, Springer-Verlag.

IV. MAJOR COURSE- MJ 15:
PRACTICALS-V:

Marks: Pr (ESE: 3Hrs) =100	Pass Marks: Pr (ESE) = 40

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:

1. Megascopic identification of ore-minerals
2. Study of microscopic properties of ore-forming minerals (Oxides and sulphides).
3. Preparation of maps: Distribution of essential ores and other economic minerals in India.
4. Computation of reservoir area, catchment area, reservoir capacity and reservoir life.
5. Merits, demerits & remedial measures based upon geological cross sections of project sites.
6. Computation of index properties of rocks, Computation of R.Q.D., R.S.R., R.M.R. and 'Q'
7. Plotting of Major Dams/ Tunnels on the outline map of India.
8. Study of Seismic/landslide zones of India.
9. Preparation and Interpretation of water level contour maps and depth to water level maps
10. The study, preparation and analysis of hydrographs for differing groundwater conditions
11. Water potential zones of India (map study).
12. Graphical representation of chemical quality data and water classification (C-S and Trilinear diagrams)
13. Simple numerical problems related to determining permeability in the field and laboratory, Groundwater flow, Well hydraulics etc.
14. Aerial Photo/imagery interpretation, identification of sedimentary, igneous and metamorphic rocks
15. Identification of geomorphic and structural features in Aerial Photo/Satellite imagery
16. Plane table and Prismatic survey
17. Identification of anomaly
18. Concept of weighted average in anomaly detection
19. Study of Geological cross-section of essential mineral deposits.
20. Megascopic study of Igneous, Sedimentary and Metamorphic rocks.

Fieldwork:

1. Geological mapping of two weeks duration in a geologically complex area and Field Work Report based on it.

Reference Books:

1. Laboratory Manual of Geology A K Sen (Modern Book Agency Pvt. Ltd. Calcutta)
2. Singh, RP. (1965). Structural Geology: A Practical Approach, Ganga Kaveri Publication House, Varanasi. 133p.
3. Bennison, G.M. (1990). An Introduction to Geological Structure and Maps, Fifth Edition, Edward Arnold. London. 5th Edition, 67p.

SEMESTER VII

I. MAJOR COURSE- MJ 16:
FOSSIL FUEL GEOLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:
To have a good understanding of the source, reservoir and cap-rocks, characterisation of reservoir rocks, Classification of reservoir pore space, permeability, migration and entrapment; To gain knowledge about the temperature-pressure conditions for the generation of oil and gas from sediments; To understand the global significance and distribution of oil/gas reservoirs; To gain knowledge of occurrence in India with special reference to Jharkhand state.

Course Learning Outcomes:
After successful completion of the course, the students are expected to:
Acquire a good understanding of petroleum source and reservoir rocks and their physical and chemical properties; Describe the mechanism responsible for the origin and accumulation of hydrocarbons; Develop a good understanding of coal formation and its properties and Coal bed methane; Evaluate and map the economic potential of sedimentary basins; Apply the knowledge to address the environmental issues and challenges during the exploration of fossil fuels.

Unit 1: Coal: Definition and Origin of Coal; Basic Classification of Coal; Fundamentals of Coal Petrology - Introduction to lithotypes, microlithotype and macerals in coal, Proximate and Ultimate analysis.

Unit 2: Coal as a fuel Coal Bed Methane (C.B.M.): global and Indian scenario, Underground coal gasification, Coal liquefaction.

Unit 3: Petroleum: Chemical Composition and physical properties of crudes in nature. Origin of petroleum.

Unit 4: Petroleum Reservoirs and Traps Reservoir rocks: general attributes, Classification of reservoir rocks, Cap rocks - definition and general properties, Hydrocarbon traps: definition, Classification of hydrocarbon traps - structural, stratigraphic and combination. Plate tectonics and global distribution of hydrocarbon reserves.

Unit 5: Indian Occurrences: Coalfields of India with special reference to Jharkhand.

Suggested Readings:

1. Chandra D. (2007). Chandra's Textbook on applied coal petrology. Jijnasa Publishing House.
2. Shelly R. C. (2014). Elements of Petroleum Geology: Third Edition, Academic Press
3. Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag.
4. Bastia, R., & Radhakrishna, M. (2012). Basin evolution and petroleum prospectively of the continental margins of India (vol. 59).

II. MAJOR COURSE- MJ 17:
GEOTECTONICS AND APPLIED STRUCTURAL GEOLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:
The course will be designed to address the enigmatic question of the initiation of plate tectonics in Geological time. The course shall address this with the evidence that is put forward to establish when plate tectonics began and how it has evolved through time. Therefore, this course shall be a transdisciplinary course that will deal with different branches of Geology (like geochemistry, geodynamics, petrology, and geophysics) and will help develop a comprehensive idea of tectonics in the students. The course outlines the geometry, principles and kinematics of the Earth's crust and lithosphere deformation. The overall aim is to give the students a better understanding of the deformation of rocks (brittle to ductile) at different scales (macroscopic to microscopic). Deformation processes and structures that develop in different tectonic settings have also been included in this course.

Course Learning Outcome:
This course will expose the students to the different views and opinions prevalent in the geodynamics of the Earth through time. This is presently an active area of research, with branches of Geology, like petrology and geochemistry, unravelling the history of terrestrial tectonics; this course will thus facilitate the students to correlate between these branches and form a holistic idea of the evolution of geodynamics through time. Students will have an idea of the different models of Archaean tectonics. Successful completion of the course will enhance critical thinking in this field in view of the present research that is going on.
The course is designed to enable the students to:

1. to have a comprehensive idea of the geometries of the natural structures that result out of deformation
2. to develop the skills of analysing natural structural data and maps of poly-deformed terranes.
3. to understand the rheology and mechanism of rock deformation at different scales.
4. To form an overall idea of the varieties of tectonics operative within the crustal domain.

Unit 1:
Study of seismic waves – structure and composition of the Earth – Radioactivity – Basic Concept of palaeomagnetism Major tectonic features of the earth-shield areas, mobile belts, rift valleys, mid-oceanic ridges, continental shelves and slopes, submarine canyons.

Unit 2:
Plate Tectonics: Concept, the geological and tectonic environment of Plate boundaries, Sea Floor Spreading, Island arcs, Hydrothermal vents; Orogeny and Orogenic cycles – Epeirogeny and evolution of plateaus. Structural and tectonic features of India. Tectonic framework of India; Structure and Origin of the Himalayas. Quaternary tectonics

Unit 3:
Mechanical principles of rock deformation; Concept of Stress, strain and the resulting ellipsoids; Factors controlling behaviour of rock material. Folds, Recognition, mechanics and causes of folding – Recognition of top and bottom of beds; Faults, recognition criteria and mechanics of faulting; Joints- Quantitative and qualitative classification of joints; Unconformities–types, recognition, significant distinction from faults and their use in dating structural events.

Unit 4:
Cleavage, Schistosity and Lineation – their description, origin and relation to major structures. Petrofabric analysis–Field and laboratory techniques–petrofabric diagrams land their Interpretation. Classification and characteristics of Tectonites, Diapirs and related structural features.

Unit 5:
Toposheet map and Geological map and their components; Geological Fieldwork instruments, Clinometer and Brunton compass, strike and dip measurements; Sampling and oriented sample and its significance; Geological mapping of igneous, sedimentary and metamorphic terrains. G.P.S. and its applications in Geology.

Suggested Readings:

1. Condie, Kent. C. (1982): Plate Tectonics and Crustal Evolution, Pergamon Press Inc.
2. Gass I.G. (1982): Understanding the Earth. Artemis Press (Pvt) Ltd. U.K.
3. Ghosh, S.K. (1993): Structural Geology: Fundamental and Modern Development. Pergamon Press.
4. Hobbs, B.E., Means, W.D. and Williams, P.F. (1976): An outline of Structural Geology, John Wiley and Sons, New York
5. Naqvi, S.M. (2005) Geology and Evolution of the Indian Plate (From Hadean to Holocene - 4Ga to 4 Ka) G.S.I., Bangalore
6. Ramsay, J.G. (1967): Folding and fracturing of rocks, McGraw Hill.
7. Windley B. (1973): The Evolving continents, John Wiley and Sons, New York.
8. N.J. Price and J.W. Cosgrove (1990) Analysis of Geological Structures, Cambridge University Press
9. Ragan, Donal M.: Structural Geology, Cambridge University Press
10. Whitten, E. H. Timothy (1966) Structural geology of folded rocks. Chicago: Rand McNally,
11. George H. Davis (2011) Structural Geology of Rocks and Regions, John Wiley and Sons
12. Fossen H (2010) Structural Geology, Cambridge University Press

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III. MAJOR COURSE- MJ 18:
ADVANCED STRATIGRAPHY AND PALAEOBIOLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:
To provide a basic understanding of rock superposition of beds through time and their relative age; understanding of stratigraphy to apply in an exploration of energy and mineral resources, codes of stratigraphy and how they have been developed; To learn about precisely stratigraphy sequences through seismic, magnetic, chemical, and absolute dating methods.

Course Learning Outcomes:
After the completion of the course, the student will be able to:
Understanding fundamentals of stratigraphic principles, different types of stratigraphic units; evolution of life through time; the spatial and temporal relationship between litho-units and their correlation with similar units in other continents; Better understanding of stratigraphy leads to the identification of potential zones of mineral and energy resources; Application of stratigraphy to characterise the evolution of life through time and mass extinctions.
After completing the course, the student will

a. understand fossils, types, fossilisation process and modes of preservation.
b. learn invertebrate and vertebrate fossils, which help to unravel the mystery of life in the past.
c. understand the evolution of life on Earth.
d. learn about rich mineral deposits like petroleum, coal, and other minerals.

Unit 1
Concept of Lithofacies and Bio-facies; Stratigraphic Correlation; Concepts of Magneto-stratigraphy and Sequence stratigraphy, Proterozoic stratigraphy -tectonic framework, geological history and evolution of Vindhyan Super Group, Cuddapah and their equivalents;

Unit 2
Palaeozoic stratigraphy: Palaeozoic formations of India with special reference to type localities, history of sedimentation, fossil content; Concept, Classification, lithology, life and age of Gondwana supergroup; Mesozoic formations of India with special reference to type localities, history of sedimentation, fossil content; Tertiary formations of North-Eastern India, Siwalik Group; Stratigraphic boundary problems–Pre Cambrian-Cambrian (P/C), Permian-Triassic (P/Tr) and Cretaceous–Tertiary (K/T) boundaries.

Unit 3
Study of Invertebrates fossils; Taphonomy and preservation. Morphology, Classification, biostratigraphy and evolutionary trends of Trilobites, Brachiopods, Bivalves, Cephalopoda, Gastropods and Echinoids.

Unit 4
Vertebrate and its Classification. Evolutionary trends in Equidae, Proboscidea and Man; Siwalik mammals and their causes of extinction.

Unit 5
Micropalaeontology; Foraminifera, dimorphism, morphology and biostratigraphy; Gondwana flora and their significance, Palynology, types of Gondwana palynomorphs and its importance; Microfossils and their significance in oil exploration.

Suggested Readings:

1. A. Sahni, (1996), Cretaceous Stratigraphy and Palaeoenvironments. G.S.I., Bangalore
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. M. Ramakrishnan & R. Vaidyanadhan (2008) Geology of India – (Vol. 1& 2) G.S.I., Bangalore
7. T.M. Mahadevan (2002), Geology of Bihar and Jharkhand. G.S.I., Bangalore

8. Naqvi, S.M. and Rogers, J.J.W. (1987): Precambrian Geology of India, Oxford University Press.
9. Naqvi, S.M. (2005) Geology and Evolution of the Indian Plate (From Hadean to Holocene - 4Ga to 4 Ka) G.S.I., Bangalore
10. Pascoe, E.H. (1968): A Manual of the Geology of India and Burma (Vols. I-IV), Govt. of India Press, Delhi.
11. Pomerol, C. (1982): The Cenozoic Era? Tertiary and Quaternary, Ellis Harwood Ltd., Halsted Press.
12. Schoch, Robert, M. (1989): Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York.
13. Boardman, R.S., Cheethan, A.M. and Rowell, A.J. (1988): Fossil Invertebrates, Blackwell.
14. Clarksons, E.N.K. (1998): Invertebrate Palaeontology and Evolution, Allen and Unwin, London.
15. Horowitz, A.S. and Potter, E.D. (1971): Introductory Petrography of Fossils, Springer Verlag.
16. Mayr, E. (1971): Population, Species and Evolution, Harvard.
17. Prothero, D.R. (2004): Bringing Fossil to Life – An Introduction to Palaeontology (2nd Ed.), McGraw Hill.
18. Raup, D.M. and Stanley, S.M. (1985): Principles of Palaeontology, C.B.S. Publ.
19. Romer A.S. (1959) The Vertebrate Story, Univ. of Chicago Press
20. Smith, A.B. (1994): Systematics and Fossil Record – Documenting Evolutionary Patterns, Blackwell.
21. Strean, C.W. and Carroll, R.L. (1989): Palaeontology – the record of life, John Wiley
22. Shrock R.R. (1953) Principles of Invertebrate Palaeontology, McGraw Hill Book Co.
23. Alfred Traverse (1988): Paleopalynology, Unwin Hyman, U.S.A.
24. Arnold (2002): Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford University Press, New York.
25. Bignot, G., Grahm and Trottman (1985): Elements of Micropaleontology, London.

IV. MAJOR COURSE- MJ 19:
PRACTICALS-VI:

Marks: Pr (ESE: 3Hrs) =100	**Pass Marks: Pr (ESE) = 40**

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:

1. Study of hand specimens of coal
2. Reserve estimation of coal and economic mineral deposits
3. Study of Geological Section Coal and Petroleum fields and identification of hydrocarbon prospect
4. Completion of outcrops in given maps; Structural problems by Stereographic Net; Plotting of Geological Sections;
5. Study of rocks in hand specimens from known Indian stratigraphic horizons and type localities;
6. Megascopic study of Invertebrate fossils;
7. Study of Molar tooth of important vertebrate fossils;
8. Study of morphological characters of selected microfossils;
9. Megascopic study of Plant Fossils;
10. Study of morphological characters of selected palynomorphs

Reference Books:

1. Laboratory Manual of Geology AK Sen (Modern Book Agency Pvt. Ltd. Calcutta)
2. Singh, RP. (1965). Structural Geology: A Practical Approach, Ganga Kaveri Publication House, Varanasi. 133p.
3. Bennison, G.M. (1990). An Introduction to Geological Structure and Maps, Fifth Edition, Edward Arnold. London. 5th Edition, 67p.

SEMESTER VIII

I. MAJOR COURSE- MJ 20:
ADVANCED CRYSTALLOGRAPHY AND DESCRIPTIVE MINERALOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Learning Objectives

To provide a fundamental understanding of crystal system, symmetry and chemistry to understand the importance of minerals in our daily life; to provide comprehensive knowledge of the structure of silicates and different groups of minerals.

Course Learning Outcomes

After the completion of the course, students will be able to:

Have a good understanding of the different symmetry elements, a comprehensive understanding of the importance and application of minerals/mineral groups, knowledge of the Structure and composition, the economic importance of minerals and building an overall knowledge in geology, knowledge of application and usage of minerals in industries.

Unit 1: External symmetry of crystals: Symmetry Elements, methods of projection, Hermann Mauguin notation. Internal symmetry of crystals: Derivation of 230 space groups, diffraction of crystals by X-rays, Bragg's law.

Unit 2: Principles of optical mineralogy: polarised light, the behaviour of isotropic and anisotropic minerals in polarised light, refractive index, pleochroism, double refraction, birefringence, the sign of elongation, interference figures, 2V, dispersion in minerals. Optic sign determination of Uniaxial and Biaxial minerals.

Unit 3: Principles of crystal chemistry; Chemical bonds, ionic radii, Coordination principle, Radius ratio; Principles of ionic substitution in minerals; Isomorphism, Exsolution, Polymorphism, Pseudo morphism; Introduction to XRF, XRD and Electron Probe Microanalysis

Unit 4: Structural Classification of silicate minerals; Description of chemistry, optical and physical properties and paragenesis of the following mineral groups: Olivine group, Garnet Group, Epidote group, Pyroxene group, Amphibole group

Unit 5: Description of chemistry, optical and physical properties and paragenesis of the following mineral groups: Mica group, Chlorite group and clay minerals, Quartz group, Feldspar group, Feldspathoids & Zeolites.

Suggested Readings:

1. Dexter Perkins, 2003. Mineralogy, Pearson Education Private Ltd.
2. Carmelo Giacovazzo, 2002. Fundamentals of crystallography, Oxford University Press
3. Boris Konstantinovich Vaĭnshteĭn, 1994. Modern Crystallography: Fundamentals of crystals, symmetry and methods of structural crystallography, Springer
4. William D. Nesse, 2009. Introduction to Mineralogy, Oxford University Press
5. Dana, E.S. – 1955. Text Book of Mineralogy, Wiley
6. Wade, F.A. and Mattox, R.E., 1960. Elements of crystallography and Mineralogy, Harmer and Brods.
7. Philips, P.C., 1971. An Introduction to Crystallography, John Wiley
8. Winchell, A.N., 1968 – Elements of optical Mineralogy, parts, I & II Wiley Eastern.
9. Berry, L.G. and Mason B, Dietrich. 1983. Mineralogy- Concept, Descriptions Determinations, Freeman
10. Burerger, M.J., 1956. Elementary Crystallography, Wiley
11. Heinrich, E.W., 1965. Microscopic identification of Minerals McGraw Hill
12. Naidu, P.R.J. C.S., 1971. Johansen's optical mineralogy, Allied
13. Haribury, C.S., 1971. Dana's Manual of Mineralogy, Wiley.
14. Deer, W.A. Howie, R.A. & Zussman, J ., 1992. Rock-forming Mineralogy Vol. 1-5, Longmans.
15. Hammond, C., 1990. Introduction to Crystallography. Oxford: Oxford University Press.
16. Klein, C., 2002. Manual of Mineral Science. 22nd Edition. New York: John Wiley and Sons.

II. ADVANCED MAJOR COURSE- AMJ 1:
GEOCHEMISTRY AND ADVANCED PETROLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Learning Objectives:

To provide comprehensive knowledge on how chemical principles are used to explain the mechanisms that control the large geological systems such as the Earth's mantle, crust, ocean and atmosphere, and the formation of the solar system; understanding of the qualitative and quantitative composition of planet Earth and solar system material; knowledge on geological processes and their geochemical signatures; understanding of geochemical behaviour of elements and isotopes and their applications in addressing the evolution of planet Earth through time including the origin of life and long term climate variability.

To develop a fundamental understanding of magmas, their origin, differentiation histories, Importance of igneous rocks in continental growth and formation of ore deposits, crystallisation and emplacement history of magmas through a study of textures and structures, magmatism through time in different geodynamic settings.

To understand the fundamentals of sedimentary processes and their products, formation and filling history of sedimentary basins in different tectonic regions, a comprehensive understanding of both clastic and chemical sedimentation processes, comprehensive understanding of varieties of sedimentary rocks. To understand the thermal history of the crust-mantle system and tectonics, factors controlling the metamorphism and metamorphism as a chemical system, kinetics of reactions, metamorphic facies, grade, and comprehensive details of various metamorphic rocks.

Course Learning Outcomes:

After completion of the course, the student will be able to develop:

Understand fundamental processes in Earth science in a geochemical context; Quantify the geological processes through trace element modelling; Understand the human influence and impacts on surface processes; Apply basic geochemical techniques to explain, interpret and predict common processes in Earth science; Develop the ability to explain, interpret and predict common processes in Earth sciences in a geochemical context; Acquire the ability to solve applied quantitative problems in Earth Sciences using geochemical principles.

Understanding of magmas, their origin, differentiation histories; Importance of igneous rocks in continental growth and formation of ore deposits, crystallisation and emplacement history of magmas; ability to understand magmatism through time in different geodynamic settings, crust-mantle system; gain knowledge of the economic potential of igneous rocks.

To describe scales of sedimentary grain size measurement and transportation history or depositional environment; To understand the texture and structure of clastic sedimentary rocks; procedure and importance of paleocurrent analysis; To comprehend the Concept of sedimentary environment and description of processes and products of different sedimentary environments. To understand the nature of metamorphic rocks and the factors controlling the metamorphism; Knowledge of phase rule as an essential tool in the study of the metamorphic assemblages; Deduce the pressure-temperature-time paths of metamorphism and its link to tectonics; Understand the spatial link between the metamorphism, fluid flow, and mineralisation.

Unit 1: Origin and abundance of elements in the Solar System and in the Earth, the cosmic abundance of elements; Geochemical Classification of Elements; Radiogenic Isotopes; Radioactive decay scheme of U-Pb, Sm-Nd, Rb-Sr, K-Ar and growth of daughter isotopes; Radiometric dating; Stable Isotopes: nature, abundance and fractionation; Laws of Thermodynamics and its application in Petrology; Age of the Earth. Geochemistry and principles of evolution of hydrosphere, biosphere and atmosphere. Geochemical cycle and principles of geochemical prospecting.

Unit 2: Nature and evolution of magma; Plate tectonics and generation of magmas; Plume magmatism and hot spots; Large igneous provinces and mafic dyke swarms; Partial melting, batch and fractional melting; Crystal fractionation and Contamination; I.U.G.S. classification of the igneous rocks and C.I.P.W. norm, Phase equilibrium - binary systems (Ab-An, Ab-Or, Di-An, Fo-Si) and their relations to magma genesis and crystallisation in the light of modern experimental works; Ternary systems (Di-Ab-An, Di-Fo-Si, Di-Fo-An, Fo-An-Si) and their relations to magma genesis and crystallisation

Unit-3: Petrogenetic significance of igneous textures; Petrology and petrogenesis of major igneous rock types with Indian examples of ultramafic, komatiite, basalt, anorthosite, granite, alkaline rocks, ophiolite, carbonatite, lamprophyre.

Unit 4: Surface processes and rock weathering; Processes of transport and generation of sedimentary rocks; Sedimentary Texture: Textural elements of clastic and non-clastic rocks, Structures: important erosional, depositional and post-depositional sedimentary structures and their significance; Provenance: Source of sediments, compositional maturity; Significance of light and heavy minerals in provenance study. Sedimentary environment and facies. Facies modelling for marine, non-marine and mixed sediments. Tectonics and sedimentation. Classification and definition of sedimentary basins. Sedimentary basins of India. Cyclic sediments. Seismic and sequence stratigraphy. Purpose and scope of basin analysis. Stratum contours and isopach maps.

Unit 5: Concept of Zones and Grades; Metamorphic facies and facies series; Fabric in metamorphism; Classification of Metamorphic Rocks; Mineralogical Phase Rule; A detailed description of each of low pressure, medium to high pressure and very high pressure with special reference to mineralogical assemblages Metamorphic Differentiation; A.C.F., A.K.F. and A.F.M. diagrams in metamorphic petrology, regional metamorphism and Ocean Floor Metamorphism; Regional and thermal metamorphism of pelitic rocks. Regional and thermal metamorphism of basic and ultrabasic rocks; Regional and thermal metamorphism of impure, silicious carbonate rocks; Metamorphism of Granitoids, Charnockite and Migmatites, Metamorphism in space and time: Plate tectonics and metamorphic processes; Paired metamorphic belts, Archaean and Proterozoic terrains; polymetamorphis.

Suggested Readings:

1. Krauskopf, K.B., 1967. Introduction to Geochemistry, McGraw Hill.
2. Mason, B. and Moore, C.B., 1991. Introduction to Geochemistry, Wiley Eastern.
3. Rollinson, H.R., 1993. Using geochemical data: Evaluation, Presentation, Interpretation. Longman U.K.
4. Bose, M.K., 1997. Igneous Petrology, World Press, Kolkata.
5. Best, M.G., 2002. Igneous and Metamorphic Petrology, Blackwell Science.
6. Cox,K.G., Bell,J.D. & Pankhurst, R.J. (1993): The Interpretation of Igneous Rocks, Champman and Hall, London.
7. Faure, G., 2001. Origin of Igneous Rocks, Springer.
8. Hall, A., 1997. Igneous Petrology, Longman.
9. LeMaitre R.W., 2002. Igneous Rocks: A Classification and Glossary of Terms, Cambridge University Press.
10. McBirney, 1994. Igneous Petrology, C.B.S. Publ., Delhi
11. Phillpotts, A.R., 1994. Principles of Igneous and Metamorphic Petrology, Prentice Hall of India.
12. Sood, M.K., 1982. Modern Igneous Petrology, Wiley-Interscience Publ., New York.
13. Srivastava, Rajesh K. and Chandra, R., 1995. Magmatism in Relation to Diverse Tectonic Settings, A.A. Balkema, Rotterdam.
14. Wilson, M., 1993. Igneous Petrogenesis, Chapman and Hall, London.
15. Winter, J.D., 2001. An Introduction to Igneous and Metamorphic Petrology, Prentice Hall, New Jersey.
16. Hoefs, J., 1980. Stable Isotope Geochemistry, Springer-Verlag.
17. Krauskopf, K.B., 1967. Introduction to Geochemistry, McGraw Hill.
18. Mason, B. and Moore, C.B., 1991. Introduction to Geochemistry, Wiley Eastern.
19. Rollinson, H.R., 1993. Using geochemical data: Evaluation, Presentation, Interpretation. Longman U.K.
20. Blatt, H., Middleton, G.V. and Murray, R.C., 1980. Origin of Sedimentary Rocks, Prentice-Hall Inc.
21. Collins, J.D., and Thompson, D.B., 1982. Sedimentary Structures, George Allen and Unwin, London.
22. Lindholm, R.C., 1987. A Practical Approach to Sedimentology, Allen and Unwin, London.
23. Miall, A.D., 2000. Principles of Basin Analysis, Springer-Verlag.
24. Pettijohn, F.J., 1975. Sedimentary Rocks (3rd Ed.), Harper and Row Publ., New Delhi.
25. Reading, H.G., 1997. Sedimentary Environments and facies, Blackwell Scientific Publication.
26. Reineck, H.E. and Singh, I.B., 1973. Depositional Sedimentary Environments, Springer-Verlag.
27. Selley, R.C., 2000. Applied Sedimentology, Academic Press.
28. Tucker, M.E., 1981. Sedimentary Petrology: An Introduction, Wiley and Sons, New York.
29. Bucher, K. and Martin, F., 2002. Petrogenesis of Metamorphic Rocks (7th Rev. Ed.), Springer–Verlag.
30. Philpotts, A.R., 1994. Principles of Igneous and Metamorphic Petrology, Prentice Hall.
31. Spry, A., 1976. Metamorphic Textures, Pergamon Press.
32. Winter, J.D., 2005. An introduction to Igneous and Metamorphic Petrology, Prentice Hall.
33. Yardley, B.W.D., Mackenzie, W.S. and Guilford, C., 1995. Atlas of Metamorphic Rocks and their textures, Longman Scientific and Technical, England.
34. Yardley, B.W., 1989. An Introduction to Metamorphic Petrology, Longman, NY
35. Best, M.G., 2004. Igneous and Metamorphic Petrology, C.B.S. Publ.
36. Winkler H.G.F., 1979. Petrogenesis of Metamorphic Rocks, Springer Verlag
37. Turner E.J., 1980. Metamorphic Petrology, McGraw Hill, NY

III. ADVANCED MAJOR COURSE- AMJ 2: GEOMORPHOLOGY AND RS-GIS IN GEOLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Learning Objectives:
To introduce comprehensive knowledge of the fundamentals of Geomorphology and Earth surface processes and their interactions between exogenic and endogenic forces; to learn about the various landforms by different agents.
Fundamentals of Remote sensing and photogeology, digital image processing, usage of G.P.S. and G.I.S. in geology.

Course Learning Outcomes:
After completion of the course, the student will be able to develop:
Knowledge of the formation of various landforms, the interplay of climate, tectonics and denudation on the landscapes, the interaction between exogenic and endogenic processes; applying the knowledge of geomorphology to land use and land cover planning.
Learn about several advanced remote sensing concepts, sensors and satellites; learn about the Geophysical remote sensing approaches covering potential fields measurement using aerial and satellite missions; Students are exposed to Digital image processing of remotely sensed data and Interpretation; and Recent trends in image processing visualisation and digital mapping.

Unit 1:
Fundamental concepts – the significance of structure, process and time; A brief account of concepts of the evolution of landforms; Characteristic features of landforms, Characteristics and types of fluvial landforms, Fluvial cycle, the Concept of peneplains, stream rejuvenation, causes and effects; Aeolian landforms Arid Cycle of erosion; Glacial landforms, periodicity of glaciation and its causes; Karst topography, the relationship of geologic structures to topography; Volcanic landforms

Unit 2:
Geomorphology of the coasts, Classification of shorelines and their evolution. Evidence of eustatic changes and their causes. Influence of lithology on relief. Development of landforms of flat-lying, tilted, folded, dome and faulted structures; Development of drainage systems, Drainage Patterns, and Drainage analysis in Geological Interpretation. Geomorphic features of India; Application of Geomorphology in groundwater, mineral and oil exploration and Engineering projects.

Unit 3:
Electromagnetic spectrum and its properties, Atmospheric Windows; Interaction of electromagnetic radiation with matter, Spectral signatures; Basic ideas of Thermal Infra-red and Microwave Remote Sensing; Photogrammetry- recent advancements and applications; Remote Sensing Satellite programmes and their characteristics;

Unit 4:
Basic principles of Image interpretation and Digital image techniques; Principles and applications of G.I.S.; Image characters and their relations with ground objects based on tone, texture and pattern; Interpretation of topographic and tectonic features; Identification of Igneous, Sedimentary and Metamorphic rock types in images;

Unit 5:
Principles of terrain analysis; Morphometric analysis; Geomorphological mapping based on the genesis of landforms; Terrain evaluation for strategic purposes.

Suggested Readings:
1. Richard J. Huggett, 2007. Fundamentals of Geomorphology, Routledge
2. Keith A. Sverdrup, Alison Duxbury, Alyn C. Duxbury, 2006. Fundamentals of Oceanography, McGraw-Hill Higher Education
3. Thornbury, W.D., 1969. Principles of Geomorphology, Wiley.
4. Worcester, P.G., 1948. A textbook of Geomorphology

5. B.W. Sparles, 1981. Geomorphology, Longman Group Ltd.
6. George Allen & Coates, 1980. Coastal Geomorphology
7. Pitty, A.F., 1972. Introduction to Geomorphology, Methuen.
8. Bloom, A.L. 1979. Geomorphology, Prentice Hall.
9. Arthur L. Bloom, 2004. Geomorphology: a systematic analysis of late Cenozoic landforms, Waveland Pr Inc,
10. Miller, V.C., 1961. Photogeology; McGraw Hill
11. Sabbins, F.F., 1985. Remote Sensing-Principles and Applications; Freeman
12. Lillesand, T.M. and Keifer, R.W., 1987. Remote Sensing and Image Interpretation; John Wiley
13. S.N. Pandey, 1987. Principles and Applications of Photogeology; Wiley Eastern, New Delhi
14. Gupta R.P., 1990. Remote Sensing Geology; Springer Verlag
15. Compton. R.R., 1962. Manual of Field Geology
16. Angela L. Coe, 2010. Geological Field Techniques, Blackwell
17. Oya, M., 2001. Applied Geomorphology for Mitigation of Natural Hazards, Springer

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IV. ADVANCED MAJOR COURSE- AMJ 3: **PRACTICALS-VII:**

Marks: Pr (ESE: 3Hrs) =100	**Pass Marks: Pr (ESE) = 40**

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:

1. Mineral formulae, calculation of important rock-forming mineral groups;
2. Microscopic identification of important rock-forming minerals;
3. Determination of Optic Signs of Uniaxial and Biaxial Minerals;
4. Determination of pleochroic scheme
5. Determination of An content in Plagioclase felspars
6. Megascopic and Microscopic studies of Igneous, Sedimentary and Metamorphic rocks.
7. Graphic representation of Modal analyses in Q.A.P. and A.P.F. diagrams
8. Calculation of C.I.P.W. Norm and Niggli Values
9. Megascopic studies of Sedimentary structures.
10. Graphic representation of chemical analyses in A.C.F., A.K.F. and A.F.M. diagrams.
11. Morphometric analysis of drainage pattern
12. Exercises on satellite imagery/photo interpretation

Reference Books:

1. Laboratory Manual of Geology AK Sen (Modern Book Agency Pvt. Ltd. Calcutta)
2. Singh, RP. (1965). Structural Geology: A Practical Approach, Ganga Kaveri Publication House, Varanasi. 133p.
3. Bennison, G.M. (1990). An Introduction to Geological Structure and Maps, Fifth Edition, Edward Arnold. London. 5th Edition, 6.

COURSES OF STUDY FOR FYUGP IN **"GEOLOGY" MINOR**

MINOR COURSE-1A (SEM-I)

I. MINOR COURSE- MN 1A:
INTRODUCTORY GEOLOGY

Marks: 15 (5 Attd. + 10 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	Pass Marks: Th (SIE + ESE) = 30

(Credits: Theory-03) **45 Hours**

Course Objectives:
To provide a fundamental understanding of Geology; Earth in the solar system along with its components and various processes, concepts of energy resources and engineering geology; basic understanding of minerals and rocks; the evolution of life through geological time scale.

Course Outcomes:
After the completion of the course, the students will be able to:
Acquire the fundamental understanding of the Geology and its various branches; Earth and its components, thorough an understanding of materials (minerals, rocks and fossils), energy resources and processes of the earth, apply the knowledge of earth science to address societal issues.

Course Content:
Unit 1: Holistic understanding of dynamic planet 'Earth" through Geology, Introduction of various branches of Earth Sciences, Application of Geology in various fields.

Unit 2: Earth in Solar System: Origin, the internal constitution of the Earth: core, mantle, crust. Atmosphere and Hydrosphere, Physiographic division of India, Earthquake and volcano, Major engineering projects of India: Dam/Reservoir, Tunnel, Bridges.

Unit 3: Energy: Renewable and Non-renewable energy, use of alternate energy sources, growing energy needs.

Unit 4: Mineral: Definition, Classification and physical properties, distribution of important economic minerals of India.
Rocks: definition and types, and basics of formation
Igneous: Magma, their types, origin and composition, Igneous texture, forms and structure
Sedimentary: Weathering and Erosion, a process of formation, texture and Structure
Metamorphic: agents and types of metamorphism, Texture and Structure.

Unit 5: Fossils and their application: Definition, processes, modes of preservation and uses, application of fossils.

Reference Books;

1. Emiliani, C. (1992). Planet earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.
2. Duff, P. M. D., & Duff, D. (Eds.). (1993). Holmes' principles of physical geology. Taylor & Francis.
3. Lutgens, F., Tarbuck, E., and Tasa, D., (2009). The Atmosphere: An Introduction to Meteorology. Pearson Publisher
4. Johnson, R.B. and De Graf, J.V. (1988). Principles of Engineering Geology, John Wiley.
5. Goodman, R.E., 1993. Engineering Geology: Rock in Engineering constructions. John Wiley & Sons, N.Y.
6. Waltham, T., (2009). Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
7. Bateman, A.M. and Jensen, M.L. (1990). Economic Mineral Deposits. John Wiley.
8. Gokhale, K.V.G.K. and Rao, T.C. (1978). Ore deposits of India their distribution and processing, Tata McGraw Hill, New Delhi
9. Earth Materials- Introduction to Mineralogy and Petrology, Cornelis Klein and Anthony Philpotts, Cambridge University Press, 2013.
10. Understanding Earth (Sixth Edition), John Grotzinger and Thomas H. Jordan, 2010, W.H. Freeman and Company, New York.
11. Schoch, R.M. (1989). Stratigraphy, Principles and Methods. Van Nostrand Reinhold
12. Prothero, D.R. (1998). Bringing fossils to life - An introduction to Palaeobiology, McGraw Hill.

II. MINOR COURSE- MN 1A PR:
MINOR PRACTICALS-1A PR

Marks: Pr (ESE: 3Hrs) = 25	Pass Marks: Pr (ESE) = 10

(Credits: Practicals-01) **30 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:

1. Distribution of Seismic zone in India
2. Locate the major engineering projects in India: Dam/Reservoir, Tunnel, Bridges.
3. Physiographic division of India
4. Distribution of renewable and non-renewable energy sources of India
5. Megascopic study of Igneous, Sedimentary and Metamorphic rocks.
6. Distribution of important economic minerals in India with special reference to Jharkhand.
7. Megascopic study of Invertebrate fossils.
8. Megascopic study of Plant fossils.

Reference Books

1. Sen, A.K.: Laboratory Manual of Geology (Modern Book Agency Pvt. Ltd. Calcutta).
2. Sinha, R.K. and Sharma, N.L. (1993): An introduction to Mineral Economics, Wiley Eastern.
3. Mahadevan, T.M. (2002): Geology of Bihar and Jharkhand, GSI, Bangalore.
4. Krishnan, M.S. (1982): Geology of India and Burma, CBS publication and distributors, Delhi.

MINOR COURSE-1B (SEM-III)

III. MINOR COURSE- MN 1B:
ESSENTIALS OF GEOLOGY, ROCKS & MINERALS

Marks: 15 (5 Attd. + 10 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	Pass Marks: Th (SIE + ESE) = 30

(Credits: Theory-03) **45 Hours**

Course Objectives:
To provide a fundamental understanding of the Earth in the solar system along with its origin, age, and its internal structure; various physical processes; concepts of plate tectonics; concepts of minerals, fossils, and rocks and its different types.

Course Learning Outcomes:
After successful completion of the course, the students are expected to:
Acquire the fundamental understanding of the Earth and its components, thorough an understanding of materials such as minerals, fossils and rocks and processes of the earth surface such as earthquake and volcanoes, and apply the knowledge of earth science to address societal issues.

Course Content:

Unit 1: Introduction to Geology, scope, sub-disciplines and relationship with other branches of Sciences, Earth in the solar system: Origin. Solar System- Introduction to Various planets- Terrestrial and Jovian Planets, Internal constitution of the Earth: core, mantle and crust.

Unit 2: Conventions in the Earth's core and production of the magnetic field; Earthquake: causes, effects and distribution; Volcanoes: types, products and distribution, Introduction to hydrosphere, biosphere and atmosphere; Origin of mountains; Elementary idea about Plate Tectonics.

Unit 3: Age of the Earth: Radioactivity and its application in determining the age of the Earth. Basic concept of:

a. Rocks: types with examples
b. Minerals: Definition and Classification.
c. Fossils: mode of preservation and uses

Unit 4: Minerals: Definitions, Classification and Physical properties of minerals. Mineral structures. Silicate Structure. Nature of light and principles of optical mineralogy. Classification of minerals based on optical properties; Petrological Microscope.; Optical properties of minerals.

Unit 5: Rocks: Definitions and types, Basics of rock formation.
Igneous rock: texture and Structure, magma: Origin and Composition, Bowen's reaction series and magmatic differentiation.
Sedimentary rocks: the process of formation, texture and Structure.
Metamorphic rocks: Agents and types of metamorphism, texture and Structure.

Reference Books:

1. Holme's Principles of Physical Geology (1992). Chapman & Hall
2. Emiliani, C. (1992). Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press.
3. Gross, M.G. (1977). Oceanography: A view of the Earth, Prentice Hall.
4. Earth Materials- Introduction to Mineralogy and Petrology, Cornelis Klein and Anthony Philpotts, Cambridge University Press, 2013.
5. Understanding Earth (Sixth Edition), John Grotzinger and Thomas H. Jordan, 2010, W.H. Freeman and Company, New York.

IV. MINOR COURSE- MN 1B PR: MINOR PRACTICALS-1B PR

Marks: Pr (ESE: 3Hrs) = 25	Pass Marks: Pr (ESE) = 10

(Credits: Practicals-01) **30 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:

1. Contour maps: profile drawing, identification and description of important topographical features.
2. Physical properties of minerals: Study and Documentation.
3. Study of physical properties of important rock-forming minerals in hand specimen:
4. Plotting of major Dams on the outline map of India, mention the name of the river and utility of the dam.
5. Study of Seismic Zones of India.
6. Observation and documentation of important structures of sedimentary and metamorphic Rocks.
7. Observation and documentation of forms of igneous rocks.
8. Study of optical properties of minerals.
9. Study of rocks in hand specimens.

Reference Books:

1. Laboratory Manual of Geology - A.K. Sen (Modern Book Agency Pvt. Ltd. Calcutta)
2. Singh, R.P. (1995) Structural Geology: A Practical Approach, Ganga Kaveri Publication House, Varanasi. 133p.
3. Bennison, G.M. (1990): An Introduction to Geological Structures and Maps, Fifth Edition, Edward Arnold. London. 5th edition, 67p.

MINOR COURSE-1C (SEM-V)

V. MINOR COURSE- MN 1C:
EARTH RESOURCES

Marks: 15 (5 Attd. + 10 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	Pass Marks: Th (SIE + ESE) = 30

(Credits: Theory-03) **45 Hours**

Course Objectives:

To understand the concept of earth resources; Ore minerals; its types, genesis, and occurrences, components and classification; knowledge of energy resources and its different types; groundwater resources and its management.

Course Learning Outcomes:

After successful completion of the course, the students are expected to have the knowledge of mineral, energy and groundwater resources, their various components, and their uses providing benefits to the society.

Course Content:

Unit 1:

Earth Resources: Definition: Mineral, Ore and Gangue, Tenor, Grade. Introduction to Essential, Critical and Strategic Minerals. A brief overview of the Classification of Mineral deposits concerning processes of formation and mode of occurrences.

Unit 2:

Definition of Energy: Primary and Secondary Energy. Renewable and Non-Renewable Sources of Energy. Environmental Dimension of Energy.

Unit 3:

Major Types and Sources of Energy: Resources of Natural Oil and Gas. Coal and Nuclear Minerals: Types and distribution. Introduction to Hydroelectric Power, Solar Energy, Wind, Wave and Biomass-based Power and Energy.

Unit 4:

Groundwater resources and their management, Groundwater resources and their role in the economic development of a country. Rainwater harvesting and artificial recharge to groundwater. Watershed management.

Unit 5:

Surface and subsurface water interaction, Groundwater level fluctuations, Basic concepts of water balance studies.

Reference Books:

1. Energy and the Environment by Fowler, J.M. (1984). McGraw-Hill Global Energy Perspectives by Nebojsa Nakicenovic 1998, Cambridge University Press.
2. Energy Resources and Systems: Fundamentals and Non-Renewable Resources by Tushar K. Ghosh and M.A. Prelas. 2009, Springer
3. Introduction to Wind Energy Systems: Hermann-Josef Wagner and Jyotirmay Mathur. 2009, Springer.
4. Renewable Energy Conversion, Transmission and Storage. Bent Sorensen, 2007, Springer.

VI. MINOR COURSE- MN 1C PR: MINOR PRACTICALS-1C PR

Marks: Pr (ESE: 3Hrs) = 25	Pass Marks: Pr (ESE) = 10

(Credits: Practicals-01) **30 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:

1. Plotting of major Indian oil fields on the map of India.
2. Plotting of major Indian coalfields on the map of India/Jharkhand.
3. Plotting of natural hazards on the map of India.
4. Megascopic study of important ore forming minerals.

Reference Books:

1. Laboratory Manual of Geology - A.K. Sen (Modern Book Agency Pvt. Ltd. Calcutta)
2. Singh, R.P. (1995) Structural Geology: A Practical Approach, Ganga Kaveri Publication House, Varanasi. 133p.
3. Bennison, G.M. (1990): An Introduction to Geological Structures and Maps, Fifth Edition, Edward Arnold. London. 5th edition, 67p.

MINOR COURSE-1D (SEM-VII)

VII. MINOR COURSE- MN 1D:
FOSSILS & THEIR APPLICATIONS

Marks: 15 (5 Attd. + 10 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	Pass Marks: Th (SIE + ESE) = 30

(Credits: Theory-03) **45 Hours**

Course Objectives:

To study the remains of animals and plants (fossils) of the geological past preserved in the rocks and how life forms had responded to climate, ecology and biogeography; also their application in geological field

Course Outcomes:

After the completion of the course, the student will be able to:
Understanding the evolution of life through time; knowledge of different fossil groups; appreciate how fossils provide the information on the paleoclimate, paleobiogeography, and paleoecology; application in hydrocarbon exploration, reservoirs correlations, pollution indicator etc.

Course Content:

Unit 1:

Introduction to fossils: Definition of fossil, fossilization processes, modes of fossil preservation and uses.

Unit 2:

Species concept: Definition of species, methods of description and naming of fossils.

Unit 3:

Introduction to various fossil groups, Brief Introduction of important fossil groups: morphology and geological history of Brachiopoda, Gastropod and lamellibranchia, Important age diagnostic fossiliferous horizons of India.

Unit 4:

Application of fossils: In the study of palaeoecology, paleobiogeography and palaeoclimate.

Unit 5:

The societal importance of fossils: implication of larger benthic and micropaleontology in hydrocarbon exploration: identification of reservoirs and their correlation. Application of spore and pollens in the correlation of coal seams. Fossils as an indicator of pollution.

Reference Books:

1. Schoch, R.M. (1989). Stratigraphy, Principles and Methods. Van Nostrand Reinhold.
2. Clarkson, E.N.K. (1998). Invertebrate Palaeontology and Evolution George Allen & Unwin
3. Prothero, D.R. (1998). Bringing fossils to life - An introduction to Palaeobiology, McGraw Hill.
4. Benton, M.J. (2005). Vertebrate palaeontology (3rd Edition). Blackwell Scientific, Oxford.
5. Colbert's Evolution of the Vertebrates: A History of the Backboned Animals Through Time, Edwin
6. H. Colbert, Michael Morales, Eli C. Minkoff, John Wiley & Sons, 1991.

VIII. MINOR COURSE- MN 1D PR:
MINOR PRACTICALS-1D PR

Marks: Pr (ESE: 3Hrs) = 25	Pass Marks: Pr (ESE) = 10

(Credits: Practicals-01) **30 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:

1. Study of fossils showing various modes of fossilization.
2. Distribution of diagnostic fossils in India.
3. Study of morphological characters of important Invertebrate fossils.
4. Drawing and labelling of various fossils.

Reference Books:

1. Laboratory Manual of Geology - A.K. Sen (Modern Book Agency Pvt. Ltd. Calcutta)
2. Singh, R.P. (1995) Structural Geology: A Practical Approach, Ganga Kaveri Publication House, Varanasi. 133p.
3. Bennison, G.M. (1990): An Introduction to Geological Structures and Maps, Fifth Edition, Edward Arnold. London. 5th edition, 67p.
