NEP FYUGP CURRICULUM

GEOLOGY HONOURS/

GEOLOGY HONOURS WITH RESEARCH PROGRAMME

SUBJECT CODE = 53

FOR UNDERGRADUATE COURSES UNDER RANCHI UNIVERSITY, RANCHI

Implemented w.e.f.
Academic Session 2025-26 & onwards

UNIVERSITY DEPARTMENT OF GEOLOGY
Basic Science Building, Morabadi Campus
Ranchi University, Ranchi - 834008, Jharkhand

Ref No. : Ps/GL-760(A)/25 Date : 24.11.2025

MEETING OF BOARD OF STUDIES (UNIVERSITY DEPARTMENT OF GEOLOGY)

A meeting of board studies was held on 24.11.2025 at 11:00 AM in the University Department of Geology, Ranchi University, Ranchi under the chairmanship of Dr. C.P Mahto, H.O.D University Department of Geology to modify the syllabus of U.G & P.G NEP curriculum to be implemented from 2025-26. The syllabus was thoroughly discussed and modifications were suggested by the members present in the meeting.In the light of suggestions of the members, the draft of the syllabus is prepared and approved; The following faculty Members were present in the meeting.

1.	Dr. C.P Mahto Head University Dept. Geology, R.U	Chair person
2.	Dr. P.K Verma Former H.O.D, University Dept. of Geology, R.U	External Member
3.	Dr. Jayant Sinha Former H.O.D, St. Xavier College, Ranchi.	External Member
4.	Mr. A.C Mishra H.O.D, Gossner College, Ranchi	Member
5.	Dr. Binita Kumari H.O.D, P.P.K College, Bundu	Member
6	Mr. Arvind Rana Bilung H.O.D, K.C.B College, Bedo	Members
7.	Dr. Chanchal Lakra Faculty, Uni. Dept. of Geology, R.U	Member
8.	Mrs. Neelu Priya Tirkey Faculty, Uni. Dept. of Geology, R.U	Member
9.	Mr. Amit Kumar Faculty, Uni. Dept. of Geology, R.U	Member
10	Dr. Nitish Priyadarshi Faculty (Contractual), Uni. Dept. of Geology, R.U	Alumnus Member
11	Dr. Suresh Kumar Samad Faculty, Uni. Dept. of Geology, R.U	Member

HEAD
University Department of Geology
Ranchi University, Ranchi

Approval by the Members of the NEP Implementation and Monitoring Committee of Ranchi University, Ranchi

The Curriculum of Bachelor's Degree (Honours)/ (Honours with Research) has been approved by the NEP Implementation and Monitoring Committee of R.U., duly forwarded by the Head of the Department; it will be offered to the students of the 4-year Undergraduate Programme (FYUGP). It is implemented from the 1st Semester of the Academic Session 2025-26 and onwards.

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Anushka Rani 10/09/2025 10/09/25 10/9/25

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HIGHLIGHTS OF FYUGP CURRICULUM

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 the **1st of July**.

ELIGIBILITY

- The selection for admission will be primarily based on the availability of seats in the Major subject and marks imposed by the institution. Merit point for selection will be based on marks obtained in the Major subject at Class 12 (or equivalent level) or the aggregate marks of Class 12 (or equivalent level) if the 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 75% overall marks or 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 a maximum of **Seven years** from the date of registration.

ACADEMIC CALENDAR

- An Academic Calendar will be prepared by the University to maintain uniformity in the UG Honours/ Honours with Research Programmes and PG Diploma Programmes, running in the colleges 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, coursework, conduct of examination and declaration of results, including semester break.
- To undergo an 8-week summer internship/ apprenticeship during the summer camp, the Academic Calendar may be scheduled for academic activities as below:
  a) Odd Semester: **From the first Monday of August to the third Saturday of December**
  b) Even Semester: **From the first Monday of January to the 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 endeavours 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 the first and second semesters.,
- 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 the first year or second year summer term, in addition to 9 credits from skill-based courses earned during the 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's Degree (Honours with Research) after a 4-year (8 semesters) programme of study to the students undertaking a 12-credit Research component in the 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 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
One credit for Practicum = 30 Hours of Practical work
One credit for Internship = 02 Weeks of Practical experience

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 a two-hour duration.
Internship – For the Exit option after any academic year of a Four-year U.G. Programme for the award of U.G. Certificate, U.G. Diploma, U.G. Degree (Level 4.5, 5 or 5.5 respectively), Students can either complete two 4-week internships worth 2 credits each or one 8-week internship for all 4 credits. This practical experience connects academic learning with real-world applications, offering valuable exposure to professional environments in their fields of study

CHANGE OF MAJOR OR MINOR COURSES

- The change of Major or Minor courses may be allowed only once after the Second Semester and before the third Semester in the FYUG Programme, depending on the provisions laid by the FYUGP and the conditions laid by the Institution. **However, the student must clear the papers (Mid Sem & End Sem both) from the previous semesters of the new subject opted in the next Examination of the coming session.**

CALCULATION OF MARKS FOR THE PURPOSE OF THE RESULT

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

PROMOTION CRITERIA

First degree programme with a single major (160+4=164 credits):

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 the Courses in an academic year, a student has to pass in minimum 11 papers out of the total 14 papers. It is further necessary

to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 4 papers out of 7 papers in Semester-II.

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 of 20 papers out of the total 26 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 3 papers out of 6 papers in Semester-IV.

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 of 27 papers out of the total 36 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 3 papers out of 5 papers in Semester VI.

vi. However, it will be necessary to procure pass marks in each of the papers before completion of the programme.

First degree programme with dual major (192+4=196 credits):

i. Please refer to the FYUGP Regulations for the detailed provisions of Double Major and Dual Degrees.

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 the Courses in an academic year, a student has to pass in minimum 11 papers out of the total 15 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 4 papers out of 8 papers in Semester-II.

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 20 papers out of the total 27 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 4 papers out of 7 papers in Semester-IV.

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 28 papers out of the total 37 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 3 papers out of 6 papers in Semester VI.

vi. However, it will be necessary to procure pass marks in each of the papers before completion of the programme.

PUBLICATION OF RESULTS

- The examination result shall be notified by the Controller of Examinations of the University in different newspapers and the same is to be posted also on the University website.
- If a student is found indulging in any malpractice/ unfair means during an 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 the next 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 to clear the backlog. Similarly, the students who have failed in any subject in an odd semester may appear in the subsequent odd semester examination to clear the backlog.

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

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COURSE STRUCTURE FOR FYUGP **'HONOURS/ RESEARCH/ PG DIPLOMA'**

Table 1: Credit Framework for Four-Year Undergraduate Programme (FYUGP) under State Universities of Jharkhand [Total Credits = 164]

Academic Level	**Level of Courses**	**Semester**	**MJ**: Discipline Specific Courses – Core or Major (80)	**AC**: Associated core courses from discipline/ Interdisciplinary/ vocational (8)		**ELC**: Elective courses may be opted from four paths [Follow table 2] (24)	**MDC**: Multidisciplinary Courses (From a pool of Courses) (9)	**AEC**: Ability Enhancement Courses (Modern Indian Language and English) (8)	**SEC**: Skill Enhancement Courses (9)	**VAC**: Value Added Courses (6)	**IKS**: (i) Indian Knowledge System (2) & **SA**: (ii) Social awareness (2)	**RC**: Research Courses (4+8)/ **AMJ**: Advanced Courses instead of Research (4+4+4)/ **PGD:** PG Diploma Level 6 (4+4+4)		**Total Credits**	**IAP**; Internship/Apprenticeship/ Project/ Vocational course/ Dissertation (4) **In between Sem I to Sem-VI**
	1	2	3 (Major- 80)	4 (Minor-32)			5	6	7	8	9	10	11	12	13
Level 4.5	Level 100-199: **Foundation or Introductory courses**	**I**	4	4	---	---	3	2	3	2	2	---	---	**20**	4
		II	4	---	4	---	3	2	3	2	2	---	---	**20**	
		Exit Point: Undergraduate Certificate provided with Summer Internship/ Project/ Vocational course/ Dissertation (4 credits)													
Level 5	Level 200-299: **Intermediate-level courses**	**III**	4+4	---		4	3	2	3	---	---	---	---	**20**	
		IV	4+4+4	---		4	---	2	---	2	---	---	---	**20**	
		Exit Point: Undergraduate Diploma provided with Summer Internship/ Project/ Vocational course/ Dissertation (4 credits)													
Level 5.5	Level 300-399: **Higher-level courses**	**V**	4+4+4+4	---		4	---	---	---	---	---	---	---	**20**	
		VI	4+4+4+4	---		4	---	---	---	---	---	---	---	**20**	
		Exit Point: Bachelor's Degree with Summer Internship/ Project/ Vocational course/ Dissertation (4 credits)												**124**	
Level 6	Level 400-499: **Advanced courses**	**VII**	4+4+4	---		4	---	---	---	---	---	4	4	**20**	---
		VIII	4+4	---		4	---	---	---	---	---	8	4+4	**20**	
		Exit Point: Bachelor's Degree with Honours/ Honours with Research/ PG Diploma Level 6												**164**	

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

Table 2: Options for Elective Minor Courses

Path A	Path B	Path C	Path D
ELC-A; Elective courses from Interdisciplinary Subjects 1 & 2 (24)	**ELC-B**; Elective courses from discipline (24)	**ELC-C**; Elective courses from vocational (24)	**ELC-D**; Elective courses from discipline for Double Major (48)
This pathway may be recommended for students who wish to develop core competency in multiple disciplines of study. In this case, the credits for the minor pathway shall be distributed among the constituent disciplines/subjects. If students pursuing FYUGP are awarded a UG Degree in a Major discipline, they are eligible to mention their core competencies in other disciplines of their choice if they have earned 12 credits each from pathway courses of two particular disciplines. In the first three years of FYUGP, this pathway is composed of one Major discipline with 60 credits from 15 courses, and two other disciplines, with 12 credits from 3 courses in each discipline. In this pathway, if the students choose one of the two disciplines for 12 credits in one discipline then they should choose a different discipline for the other 12 credits. If the students continue to the fourth year of FYUGP, the students need to earn an additional 4 credits in both disciplines.	This pathway may be recommended to those students who wish for an in-depth study in more than one discipline with a focus on one discipline (Major) and relatively less focus on the other (Minor). If students exit at the end of the third year of FYUGP, they are awarded a Major Degree in a particular discipline and a Minor in another discipline of their choice, if they earn a minimum of 24 credits from the courses in the Minor discipline. If the students continue to the fourth year of FYUGP, they should earn a minimum of 32 credits in the Minor discipline, to be eligible for a UG Degree (Honours) with a Major and a Minor. For this, in the fourth year, they should earn an additional minimum of 8 credits through 2 courses in the Minor discipline.	This pathway may be recommended to those students who wish for exposure to a vocational discipline in addition to the in-depth study in the Major discipline. The credit requirements for Major and Vocational Minor disciplines in this pathway are the same as those for Major with Minor pathway, except that the Minor courses are in a vocational discipline. If students exit at the end of the third year of FYUGP, they are awarded a Major Degree in a particular discipline and a Minor in vocational discipline of their choice, if they earn a minimum of 24 credits from the Vocational courses. If the students continue to the fourth year of FYUGP, they should earn a minimum of 32 credits in the vocational discipline. For this, in the fourth year, they should earn an additional minimum of 8 credits through 2 courses in the Vocational discipline.	To secure the required minimum credits in each discipline, students who wish to opt for a Double Major should include the credits earned by them from the Multi-Disciplinary Courses, Skill Enhancement Courses, and Value-Added Courses offered by the respective Major disciplines. The Double Major pathway is extended to the fourth year. Shifting to a double major from a minor in the third semester will be allowed subject to clearance of the courses of double major (not studied earlier) in succeeding sessions. In the fourth year, the student can continue to earn the required credits in either Major A or Major B to qualify for a UG Degree (Honours)/ UG Degree (Honours with Research) in A or B. If he/she opts to continue with Major B in the fourth year, he/she should earn an additional 16 credits of 300-399 level in Major B through mandatory online courses. The institution will not provide the courses in physical mode in the fourth year of this segment.

Table 3: Credit Distribution in Elective Minor Courses during the Four Years of FYUGP

Academic Level	**Level of Courses**	**Semester**	**Path A** **ELC**; Elective courses from Interdisciplinary Subjects 1 & 2 (24)		**Path B** **ELC**; Elective courses from the discipline (24)	**Path C** **ELC**; Elective courses from vocational (24)	**Path D** **ELC**; Elective courses from the discipline for Double Major (64)
	1	2	3A. Subject 1	3B. Subject 2	4	5	6
Level 4.5	Level 100-199: **Foundation or Introductory courses**	**I**	---	---	---	---	4+4
		II	---	---	---	---	4+4
		Exit Point: Bachelor's Degree with Hons. with Research					
Level 5	Level 200-299: **Intermediate-level courses**	**III**	4	---	4	4	4+4
		IV	---	4	4	4	4+4
		Exit Point: Bachelor's Degree with Hons.					
Level 5.5	Level 300-399: **Higher-level courses**	**V**	4	---	4	4	4+4
		VI	---	4	4	4	4+4
		Exit Point: P.G. Diploma Degree					
Level 6	Level 400-499: **Advanced courses** Hons with Research (>7.5 CGPA)/ Honours/ PG Diploma	**VII**	4	---	4	4	4+4
		VIII	---	4	4	4	4+4
		Exit Point: (A) Bachelor's Degree with Hons. with Research/ (B) Bachelor's Degree with Hons./ (C) P.G. Diploma Degree					

COURSES OF STUDY FOR FOUR-YEAR UNDERGRADUATE PROGRAMME 2025 onwards

Table 4: Semester-wise Course Code and Credit Points for Single Major during the First Three Years of FYUGP

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
I	AEC-1	Language and Communication Skills (MIL-1; Modern Indian language Hindi/ English)	2	7 Papers (20 credits)
	VAC-1	Value Added Course-1	2	
	IKS-1	Indian Knowledge System-I (Foundation Course)	2	
	SEC-1	Skill Enhancement Course-1	3	
	MDC-1	Multi-disciplinary Course-1	3	
	AC-1	Associated core courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-1	Major paper 1 (Disciplinary/ Interdisciplinary Major)	4	
II	AEC-2	Language and Communication Skills (MIL-1; Modern Indian language English/ Hindi)	2	7 Papers (20 credits)
	VAC-2	Value Added Course-2	2	
	SA	Social Awareness Activities	2	
	SEC-2	Skill Enhancement Course-2	3	
	MDC-2	Multi-disciplinary Course-2	3	
	AC-2	Associated core courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-2	Major paper 2 (Disciplinary/ Interdisciplinary Major)	4	
III	AEC-3	Language and Communication Skills (MIL-2; MIL including TRL)	2	6 Papers (20 credits)
	SEC-3	Skill Enhancement Course-3	3	
	MDC-3	IKS as a Multi-disciplinary Course-3	3	
	ELC-1	Elective courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-3	Major paper 3 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-4	Major paper 4 (Disciplinary/ Interdisciplinary Major)	4	
IV	AEC-4	Language and Communication Skills (MIL-2; MIL including TRL)	2	6 Papers (20 credits)
	VAC-3	Value Added Course-3	2	
	ELC-2	Elective courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-5	Major paper 5 (Disciplinary/ Interdisciplinary Major having IKS)	4	
	MJ-6	Major paper 6 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-7	Major paper 7 (Disciplinary/ Interdisciplinary Major)	4	
V	ELC-3	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-8	Major paper 8 (Disciplinary/ Interdisciplinary Major)	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	
VI	ELC-4	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	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	
Total Credits, excluding one Internship (IAP) of 4 credits =			**120**	**120**

Note: It is mandatory to take One Internship of 4 credits in any one of the semesters during the first three years in FYUGP or before exit at any of the exit points if a student wishes to opt for the same.

Table 5A: Semester-wise Course Code and Credit Points for Single Major during the Fourth Year of FYUGP for Bachelor's Degree (Honours with Research)

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
VII A	ELC-5	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-16	Major paper 16 (Research Methodology)	4	
	MJ-17	Major paper 17 (Disciplinary/Interdisciplinary Major)	4	
	MJ-18	Major paper 18 (Disciplinary/Interdisciplinary Major)	4	
	RC-1	Research proposal – Planning & Techniques (Disciplinary/Interdisciplinary Major)	4	
VIII A	ELC-6	Elective courses from discipline/ Interdisciplinary/ vocational	4	4 Papers (20 credits)
	MJ-19	Major paper 19 (Disciplinary/Interdisciplinary Major)	4	
	MJ-20	Major paper 20 (Disciplinary/Interdisciplinary Major)	4	
	RC-2	Research Internship/Field Work/Project/Dissertation/Thesis	8	
		Total Credits, excluding one Internship of 4 credits =	**160**	**160**

Table 5B: Semester-wise Course Code and Credit Points for Single Major during the Fourth Year of FYUGP for Bachelor's Degree (Honours)

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
VII B	ELC-5	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	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	
	AMJ-1	Advanced Major pape-1 (Disciplinary/Interdisciplinary Major)	4	
VIII B	ELC-6	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-19	Major paper 19 (Disciplinary/Interdisciplinary Major)	4	
	MJ-20	Major paper 20 (Disciplinary/Interdisciplinary Major)	4	
	AMJ-2 AMJ-3	Advanced Major paper-2 (Disciplinary/Interdisciplinary Major) Advanced Major paper-3 (Disciplinary/Interdisciplinary Major)	4 4	
		Total Credits, excluding one Internship of 4 credits =	**160**	**160**

Table 5C: Semester-wise Course Code and Credit Points for Single Major during the Fourth Year of FYUGP for Bachelor's Degree (with Postgraduate Diploma)

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
VII C	ELC-5	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	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	
	JOC-1	Skill based Job Oriented paper (Disciplinary/Interdisciplinary Major)	4	
VIII C	ELC-6	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-19	Major paper 19 (Disciplinary/Interdisciplinary Major)	4	
	MJ-20	Major paper 20 (Disciplinary/Interdisciplinary Major)	4	
	JOC-2	Skill based Job Oriented paper (Disciplinary/Interdisciplinary Major)	4	
	JOC-3	Skill based Job Oriented paper (Disciplinary/Interdisciplinary Major)	4	
		Total Credits, excluding one Internship of 4 credits =	**160**	**160**

AIMS OF BACHELOR'S DEGREE PROGRAMME IN GEOLOGY

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

(i) The curriculum of B.Sc. (Hons) Geology is framed under the National Education Policy (N.E.P. 2022) to prepare its students for society.

(ii) Each program vividly elaborates its nature and promises the outcomes to be accomplished by studying the courses.

(iii) 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.

(iv) Being a fast, economically developing country with depleting natural resources, acute shortage of energy, natural disasters, and many environmental hazards.

(v) 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.

(vi) It is an exciting course with both fundamental and applied utility.

(vii) To provide the latest subject matter, both theoretical as well as practical, such a way to foster their core competency and discovery learning. A Geology graduates as envisioned in this framework would be sufficiently competent in the field to undertake further discipline-specific studies, as well as to begin domain-related employment.

(viii) To mold a responsible citizen who is aware of most basic domain-independent knowledge, including critical thinking and communication.

(ix) To enable the graduate, prepare for national as well as international competitive examinations, especially UGC-CSIR NET and UPSC Civil Services Examination.

PROGRAM LEARNING OUTCOMES

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

(i) To provide a solid scientific foundation in Earth sciences, including mineralogy, petrology, structural geology, and stratigraphy.

(ii) To develop a clear understanding of Earth's materials, processes, history, and the interactions between geology, environment, and society.

(iii) To equip students with both theoretical knowledge and practical skills in field mapping, sampling, and geological survey.

(iv) To enable students to identify, classify, and interpret minerals, rocks, fossils, and geological structures.

(v) To develop competence in interpreting geological maps, sections, and geospatial data.

(vi) To foster the ability to collect, organize, analyses, and interpret geological and scientific data using appropriate methods and tools.

(vii) To introduce students to natural resources (minerals, coal, oil, gas, groundwater) and their exploration, evaluation, and responsible use.

(viii) To sensitize students to environmental and geotechnical issues such as landslides, earthquakes, floods, and land-use planning.

(ix) To promote awareness of sustainable development and the importance of conserving geological and environmental resources.

(x) To develop basic skills in paleontology and stratigraphy for reconstructing Earth history and past environments.

(xi) To prepare students for careers in mineral exploration, groundwater studies, petroleum geology, geotechnical engineering, and environmental consulting.

(xii) To provide exposure to laboratory techniques, instrumentation, and analytical procedures relevant to geology.

(xiii) To cultivate scientific reasoning, critical thinking, and problem-solving abilities in the context of geological problems.

(xiv) To inculcate communication skills for presenting geological information clearly to both technical and non-technical audiences.

(xv) To prepare students for higher-degree programme (M.Sc., Ph.D.) and research in geology and related disciplines.

(xvi) To develop familiarity with Indian geological terrains, stratigraphy, and key mineral and fossil-bearing formations.

(xvii) To imbibe professionalism, ethical standards, and responsibilities of a geoscientist in industry, academia, and government organizations.

(xviii) To encourage field-based learning, safety awareness, and observational skills during geological excursions.

(xix) To integrate modern technologies (GIS, remote sensing, digital mapping) into geological investigations.

(xx) To produce graduates who can contribute to national development in areas such as natural-hazard mitigation, resource management, and environmental protection.

(xxi) To help students build up a progressive and successful career in Geology.

SEMESTER WISE COURSES IN GEOLOGY HONOURS **2025 onwards**

Table 6: Semester-wise Course Code and Credit Points of Major Courses in Geology

Semester	Courses		Examination Structure			
	Code	Courses in NEP FYUGP Syllabus of Geology Session 2025-26 & onwards	Credits	Mid Semester Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical/ Viva (F.M.)
I	MJ-1	Earth Science System	4	25	75	---
	SEC-1	Geomorphology and Geotectonics	3	---	75	---
II	MJ-2	Stratigraphy & Paleontology	4	25	75	---
	SEC-2	Basics of Geochemistry	3	---	75	---
III	MJ-3	Mineralogy and Crystallography	4	25	75	---
	MJ-4	Practical-I	4	---	---	100
	SEC-3	Elementary Computer Application Softwares	3	---	75	---
IV	MJ-5	IKS: Geotourism & Geoheritage Studies	4	25	75	---
	MJ-6	Fundamentals of Petrology	4	25	75	---
	MJ-7	Practical-II	4	---	---	100
V	MJ-8	Engineering Geology	4	25	75	---
	MJ-9	Economic and Mining Geology	4	25	75	---
	MJ-10	Geochemistry and Isotope Geology	4	25	75	---
	MJ-11	Practical-III	4	---	---	100
VI	MJ-12	Environmental Geology	4	25	75	---
	MJ-13	Fossil fuel	4	25	75	---
	MJ-14	Hydrology	4	25	75	---
	MJ-15	Practical-IV	4	---	---	100
VII	MJ-16	Research Methodology in Geosciences	4	25	75	---
	MJ-17	Advanced Structural Geology	4	25	75	---
	MJ-18	Practical-V	4	---	---	100
	AMJ-1/	Geomorphology and RS-GIS OR	4	25	75	---
	RC-1	Research Planning & Techniques	4	25	75	---
VIII	MJ-19	Advanced Petrology	4	25	75	---
	MJ-20	Practical-VI	4	---	---	100
	AMJ-2	Oceanography and Climatology	4	25	75	---
	AMJ-3/	Practical-VII (Oceanography and Climatology)	4	---	---	100
	RC-2	Project Dissertation/ Research Internship/ Field Work	8	50	---	150

***** It is mandatory to take Either One Internship of 4 credits or Two Internships of 2 credits each in any one of the semesters during the first three years in FYUGP or before exit at any of the exit points if a student wishes to opt for the same.

Table 7: Semester-wise Course Code and Credit Points of Minor Courses in Geology

Courses		Examination Structure			
Code	**Minor Courses in NEP FYUGP Syllabus of Economics** Session 2025-26 & onwards	**Credits**	**Mid Semester Theory (F.M.)**	**End Semester Theory (F.M.)**	**End Semester Practical/ Viva (F.M.)**
MN-A	Introductory Geology	4	15	60	25
MN-B	Essentials of Geology, Rocks and Minerals	4	15	60	25
MN-C	Earth Resources	4	15	60	25
MN-D	Fossils and Their Applications	4	15	60	25
MN-E	Structural Geology	4	15	60	25
MN-F	Hydrogeology	4	15	60	25
MN-G	Engineering and Environmental Geology	4	15	60	25

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 50 marks):

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

B. (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.

C. (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.

D. (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 MID/ END SEMESTER EXAMINATIONS

Question format for **15 Marks**:

Subject/ Code

F.M. =15 **Time** = 1 Hr. 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 subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

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

Group B

2. ..... [10]
3. ..... [10]

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

Question format for **20 Marks**:

Subject/ Code

F.M. =20 **Time** = 1 Hr. 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 subparts of a question in one place.
v. Numbers in the right indicate full marks for 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 the Theory Examination.

Question format for **50 Marks**:

Subject/ Code

F.M. =50 **Time** = 1.5 Hrs. 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 subparts of a question in one place.
v. Numbers in the right indicate full marks for 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 the Theory Examination.

Question format for **60 Marks**:

Subject/ Code

F.M. =60 **Time** = 3 Hrs. 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 subparts of a question in one place.
v. Numbers in the right indicate full marks for 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 the Theory Examination.

Question format for **75 Marks**:

Subject/ Code

F.M. =75 **Time** = 3 Hrs. 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 subparts of a question in one place.
v. Numbers in the right indicate full marks for 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 the Theory Examination.

Question format for **100 Marks**:

Subject/ Code

F.M. =100 **Time** = 3 Hrs. 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 subparts of a question in one place.
v. Numbers in the right indicate full marks for 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 the Theory Examination.

SEMESTER I

I. MAJOR COURSE –MJ 1:
EARTH SCIENCE SYSTEM

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

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

Course Objectives:

1. To introduce Earth's origin, internal structure, and relationships with planetary systems.
2. To examine dynamic geological processes including earthquakes, volcanism, and plate tectonics.
3. To explore weathering, stratigraphy, and geochronological principles for earth history reconstruction.
4. To develop skills in topographic interpretation, structural geology fundamentals, and field recognition.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Describe solar system evolution, Earth's internal structure/composition, and origins of hydrosphere/atmosphere/biosphere with age determination concepts.
2. Analyze earthquake/volcanic distributions, plate boundary dynamics (convergent/divergent/transform), sea floor spreading, continental drift, and isostatic principles.
3. Explain weathering/soil formation processes, stratigraphic laws (superposition, faunal succession), geological time scale, and uniformitarianism applications.
4. Measure dip/strike using clinometer compass, interpret topographic effects on outcrops, and identify structural features (folds, faults, joints, unconformities) in geological contexts.

Course Content:

Unit 1: Introduction to geology, scope, sub disciplines and relationship with other branches of science; The Universe and the Big Bang Theory, Origin of the Solar System, Earth and planetary system terrestrial planets and moons; size, shape, internal structure and composition of the Earth; Origin of hydrosphere and atmosphere, biosphere; Origin of oceans, continents and mountains; Age of the Earth.

Unit 2: Earthquakes: causes, geological effects and their measurement, distribution of earthquake belts; Volcanoes - types, causes and geological effects, distribution of volcanic belts; Relationship of earthquakes with volcanic belts, Concept of plate Tectonics: Convergent, Divergent, transform plate boundary, Sea floor spreading & continental drift theory, Concept of Isostasy.

Unit 3: Weathering and erosion; Soil, soil formation, soil profile and soil type; 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.

Unit 4: Topography and its representation; Clinometer compass and its use; Dip and strike; Outcrop, effects of topography on outcrop; Forms of igneous bodies: concordant and discordant Fold morphology, their geometric and genetic classification and causes of folding.

Unit 5: Faults - parts of faults, Geometric and genetic classification of Faults (normal, reverse and strike-slip faults), Recognition of faults in the field and causes of faulting; Joints- their geometric classification; Unconformity, its kinds and significance; onlap, offlap, Overlap; Outlier and inlier.

Reference Books:

1. Billings, M.P. (1972): Structural Geology, Prentice Hall.
2. Dennis, J.G. (1972): Structural Geology, Ronald Press Company, New York.
3. Hills, E.S. (1963): Elements of Structural Geology, Farrold and Sons, London.
4. Holmes, Arthur (1992): Principles of Physical Geology, Vol. 1, Chapman and Hall, London.
5. Leet, L.D. and Judson, S. (1969): Physical Geology, Prentice Hall.
6. Marshak, S. (2018). Earth: Portrait of a planet (6th ed.). W.W. Norton & Company.
7. Moores, E. M., & Twiss, R. J. (1995). Tectonics. W.H. Freeman.
8. Press, F., Siever, R., Grotzinger, J., & Jordan, T. H. (2011). Understanding earth (6th ed.). W.H. Freeman.
9. Ramsay, J.G. and Huber, M.I. (2000): Techniques of Modern Structural Geology, Vol. III, Academic Press.
10. Sen, A. K. (1995). Laboratory manual of geology. Modern Book Agency Private Ltd.
11. Singh, R. P. (1995): Structural Geology, A Practical Approach, Ganga Kaveri Publ., Varanasi.
12. Tarbuck, E. J., Lutgens, F. K., & Tasa, D. (2020). Essentials of geology (14th ed.). Pearson.

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

1. To introduce geomorphological principles, cycles, and mapping techniques.
2. To examine endogenous and exogenous processes shaping Earth's surface features.
3. To explore continental dynamics through palaeomagnetism and sea-floor spreading.
4. To analyse plate tectonics theory and Earth's interacting spheres.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Apply geomorphological cycle concepts and create geomorphic maps using standard tools and techniques.
2. Differentiate epirogenic (degradation/aggradation), hypogene (diastrophism/volcanism), and extraterrestrial processes with examples of wind, glacier, river, groundwater, and ocean work.
3. Explain continental drift evidence, sea-floor spreading at mid-oceanic ridges, and paleomagnetic applications in plate reconstruction.
4. Describe plate margins (convergent/divergent/transform), orogenic processes, island arcs, deep sea trenches, and interactions among Earth's atmosphere, hydrosphere, lithosphere, biosphere, and human influences.

Course Content:

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

Unit 2: Epigenic/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 continent4al 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.

Reference Books:

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

SEMESTER II

I. MAJOR COURSE- MJ 2:
STRATIGRAPHY & 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

1. To familiarize students with stratigraphic principles, codes, and India's physiographic-tectonic framework.
2. To examine the Precambrian and Phanerozoic stratigraphic successions, basins, and volcanic provinces of India.
3. To introduce fossilization processes, taxonomy, and biostratigraphic applications in stratigraphic correlation.
4. To develop skills in analysing key fossil groups, their geological history, and paleoenvironmental significance.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Explain lithostratigraphy, biostratigraphy, chrono-stratigraphy, and other methods per the International Stratigraphic Code, including India's tectonic subdivisions.
2. Describe the geology, structure, and economic potential (e.g., hydrocarbons) of Precambrian cratons (Dharwar, Singhbhum), Proterozoic basins (Vindhyan, Cuddapah), Gondwana, and Phanerozoic sequences.
3. Identify fossilization modes, apply species concepts and index fossils for biostratigraphic zoning, and correlate stratigraphic units across Indian basins.
4. Analyse morphology, evolutionary history, and stratigraphic roles of key fossils like trilobites, brachiopods, cephalopods, vertebrates (e.g., horse evolution), and Gondwana flora/ichnofossils.

Course Content:

Unit 1: Principles of stratigraphy, Introduction to lithostratigraphy, biostratigraphy, chrono-stratigraphy, seismic stratigraphy, chemo-stratigraphy, Magneto-stratigraphy; International Stratigraphic Code-development of standardized stratigraphy nomenclature, Principles of stratigraphic analysis and Physiographic and tectonic subdivisions of India. Introduction to India's physiographic and tectonic subdivision, Introduction to Indian Shield.

Unit 2: Precambrian-Stratigraphy of India: Precambrian geology of Singhbhum and Dharwar, Introduction to Proterozoic basins of India; Geology of Vindhyan and Cuddapah basins of India.

Unit3: Phanerozoic Stratigraphy of India: Geology, Structure and hydrocarbon potential of Gondwana Basins. Mesozoic stratigraphy of India: Triassic succession of Spiti, Jurassic of Kutch, Cretaceous succession of Cauvery basins; Cenozoic stratigraphy of India: Siwalik successions, Assam Basins. Volcanic provinces of India and Stratigraphy boundaries: Deccan, Rajmahal.

Unit 4: Fossilization and fossil record, Fossilization processes and modes of preservation. Taxonomy and Species concept with application of fossil and Stratigraphy, Biostratigraphy, Biozones index fossil correlation fossil and paleoenvironmental Analysis.

Unit 5: Invertebrates brief Introduction of important fossil groups: morphology and geological history trilobites. Brachiopoda. Gastropod, Cephalopoda, and Lamellibranchia. Vertebrates and other fossil: Evolution of horse and intercontinental migrations. Human evolution. Gondwana Flora Introduction to Ichnology.

Reference Books:

1. Benton, M. (2009). Vertebrate Paleontology, John Wiley & Sons.
2. Clarkson, E.N.K (2012). Invertebrate Paleontology and evolution 4th Edition by Blackwell Publishing.
3. Doyle, P & Bennett, M.R. (1996). Unlocking the Stratigraphic Record. John Wiley
4. Krishnan, M.S. (1982). Geology of India and Burma, C.B.C Publisher, Delhi.
5. Ramakrishnan M. & Vidyanadhan, R. (2008). Geology of India Volumes 1 & 2, Geological Society of India, Bangalore.
6. Valdiya, K.S. (2010). The making of India. Macmillan India Pvt. Ltd.

II. 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

1. To introduce crystal chemistry fundamentals, chemical bonding, and periodic table applications in geology.
2. To examine cosmic abundances, geochemical evolution, and major element distributions across rock types.
3. To explore Goldschmidt's classification and trace element behaviours in geological systems.
4. To analyse geochemical thermodynamics, isotopes, and evolution of Earth's spheres with prospecting applications.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Explain crystal chemistry concepts including coordination numbers, ionic/covalent bonds, colloids, and ion exchange processes in geological contexts.
2. Describe cosmic element abundances, geochemical differentiation of Earth, and major biogeochemical cycles influencing planetary evolution.
3. Apply Goldschmidt's classification to predict major, minor, and trace element distributions across igneous, metamorphic, and sedimentary rocks.
4. Analyse isomorphism/polymorphism, stable/radiogenic isotope systems, geochemical thermodynamics, and apply principles to hydrosphere/biosphere evolution and mineral prospecting.

Course Content:

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: Goldschmidt'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.

Reference Books:

1. Faure, G. (1998). Principles and applications of geochemistry: A comprehensive textbook for geology students (2nd ed.). Prentice Hall.
2. Hoefs, J., 1980. Stable Isotope Geochemistry. Springer-Verlag.
3. Klein, C. and Hurlbut, C.S., 1993. Manual of Mineralogy. John Wiley and Sons, New York.
4. Krauskopf, K. B., & Bird, D. K. (1995). Introduction to geochemistry (3rd ed.). McGraw-Hill.
5. Krauskopf, K.B., 1967. Introduction to Geochemistry. McGraw Hill.
6. Mason, B. and Moore, C.B., 1991. Introduction to Geochemistry. Wiley Eastern.
7. Misra, K. C. (2009). Understanding mineral deposits. Springer.
8. Nesse, W. D. (2012). Introduction to mineralogy (2nd ed.). Oxford University Press.
9. Rollinson, H.R., 1993. Using geochemical data: Evaluation, Presentation, and Interpretation. Longman
10. White, W. M. (2013). Geochemistry. Wiley-Blackwell.

SEMESTER III

I. MAJOR COURSE- MJ 3:
MINERALOGY AND CRYSTALLOGRAPHY

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

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

Course Objectives

1. To introduce crystal morphology, symmetry, and classification into crystal systems.
2. To explore crystal projections, structural chemistry, and stereographic representations.
3. To examine physical/chemical properties and structures of rock-forming silicate/non-silicate minerals.
4. To develop skills in optical mineralogy using petrological microscopes for mineral identification.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Describe crystal parameters, indices, symmetry elements, and classify crystals into the six systems (normal class).
2. Construct stereographic projections and explain crystal chemistry, including CCP/HCP structures.
3. Identify and characterize common rock-forming minerals by physical, chemical, and structural properties.
4. Use optical microscopy to recognize key minerals (e.g., olivine, pyroxene, amphibole, quartz, mica, feldspar) based on light properties and diagnostic features.

Course Content:

Unit 1: Fundamentals of Crystallography: Morphology, Symmetry, and Classification:

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

Unit 2: Crystal Symmetry, Projections, and Structural Chemistry:

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: Classification, Properties, and Crystal Structures:

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: Optical Mineralogy: Properties of Light and Microscopic Identification of Rock-Forming Minerals:

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: Physical, Chemical, and Optical Properties of Key Rock-Forming Mineral Groups

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

Reference Books:

1. Dana, J.D., & Dana, E.S. (1948). Dana's textbook of mineralogy (7th ed., rev. by C. S. Hurlbut Jr.). John Wiley & Sons.
2. Deer, W.A., Howie, R.A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.
3. Kerr, P.F. (1959). Optical Mineralogy. McGraw-Hill.
4. Klein, C., & Philpotts, A.R. (2017). Earth materials: Introduction to mineralogy and petrology (2nd ed.). Cambridge University Press.
5. 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.
6. Nesse, W.D. (2012). Optical mineralogy (4th ed.). Pearson.
7. Nesse, W.D. (2013). Petrography: An introduction to the study of rocks in thin section (4th ed.). W.H. Freeman.
8. Perkins, D., & Ruscinsky, K. (2011). Mineralogy (3rd ed.). Pearson.
9. Read, H.H. (1988). Elements of Mineralogy. Surjeet Publication.
10. Verma, P.K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.

II. MAJOR COURSE- MJ 4:
PRACTICAL-I

Marks: Pr (ESE: 6Hrs) =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 6Hrs 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. Observation and documentation of the symmetry of crystals
2. Measurement of crystal angles using a contact goniometer.
3. Drawing and labeling of crystal forms with Miller indices.
4. Study of physical properties of common rock-forming minerals in hand specimens.
5. Study of some essential silicate minerals under an optical microscope and their characteristic properties.
6. Megascopic study of Minerals-Silicate-Olivine, Granet, Andalusite, Muscovite, Biotite, Quartz, Orthoclase, Plagioclase, Microcline, Beryl, Kyanite, Sillimanite, Hornblende, Tourmaline, Serpentine.
7. Preparation of Geological cross section of different maps (Dip & Strike)
8. Study the different rock types of Indian Stratigraphy.
9. Stereographic projection of different crystal system.

Reference Books:

1. Dana, J.D., & Dana, E.S. (1948). Dana's textbook of mineralogy (7th ed., rev. by C. S. Hurlbut Jr.). John Wiley & Sons.
2. Deer, W.A., Howie, R.A., & Zussman, J. (2013). Rock-forming minerals: An introduction to their properties, occurrence, and identification (5th ed., Vol. 1). The Geological Society.
3. Marshak, S. (2016). Laboratory manual for introductory geology (3rd ed.). W.W. Norton & Company.
4. Nesse, W.D. (2012). Optical mineralogy (4th ed.). Pearson.
5. Perkins, D. (2011). Mineralogy (3rd ed.). Pearson.
6. Sen, A.K. (1995). Laboratory manual of geology. Modern Book Agency Private Ltd.
7. Wadia, D.N. (1997). Geology (4th ed.). Tata McGraw-Hill Publishing Company.

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

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

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

Course Objectives:

1. Introduce fundamental computer concepts, hardware, software, and operating systems to enable efficient digital tool usage in academic tasks.
2. Develop practical skills in MS Office applications (Word, Excel, PowerPoint) for creating educational documents, data analysis, and presentations.
3. Familiarize learners with internet tools, email, and e-governance for research collaboration and online resource access.
4. Explore digital education concepts to integrate e-learning technologies into geology teaching and curriculum design.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Identify and explain core computer components, hardware-software relationships, and Windows 11 operations for basic system management.
2. Create, format, and manage professional documents in MS Word, including tables, headers, and printing for academic reports.
3. Analyze data using MS Excel features like formulas, charts, pivot tables, and sorting to process geological datasets effectively.
4. Design engaging presentations in MS PowerPoint with animations and master slides, while utilizing internet tools for e-governance and email communication.

Course Content:

1. Basic Concept of Computer: What is a Computer, Applications of Computer, Types of Computers, Components of a Computer System, Central Processing Unit (CPU).

2. Concepts of Hardware: Input Devices, Output Devices, Computer Memory, Types of Memory, Processing Concept of Computer.

3. Operating system: Operating System, 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

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.

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. 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. Microsoft Excel (Spreadsheet): Spreadsheet Concepts, Creating, Saving and Editing a Workbook, Inserting, Deleting Worksheets, Formatting worksheet, Excel Formula, Concept of charts and Applications, Pivot table, Goal Seek, Data filter, data sorting and scenario manager, printing the spreadsheet.

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

9. Digital Education: Introduction & Advantages of Digital Education, Concept of e-learning, Technologies used in e-learning.

Reference Books:

1. Corner, D.E. (2009). The Internet book (4th ed.). Prentice Hall.
2. Goel, A. (2010). Computer fundamentals. Pearson Education India.
3. Mathur, N. (2010). Fundamentals of computer. APH Publishing Corporation.
4. Powell, N. (2021). Windows 11 user guide for beginners and seniors. Independently published.
5. Preppernau, J. (2015). Microsoft PowerPoint 2016 step by step. Microsoft Press.
6. Singh, N. (2021). Computer fundamentals (Basic computer). T. Balaji Publications.
7. Wang, W. (2018). Microsoft Office 2019 for dummies. Wiley.

8. Rajaraman, V., & Adabala, N. (2018). Fundamentals of computers (7th ed.). PHI Learning Pvt. Ltd.
9. Sinha, P.K., & Sinha, P. (2017). Computer fundamentals (7th ed.). BPB Publications.
10. Thareja, R. (2014). Fundamentals of computers. Oxford University Press.
11. Balagurusamy, E. (2019). Fundamentals of computers. McGraw Hill Education.
12. Norton, P. (2021). New perspectives on computer concepts 2021: Introductory (19th ed.). Cengage Learning.
13. Vermaat, C., Freund, S.M., Holschuh, J., Schmieder, C., Last, M.Z., & Cameron, A. (2022). Discovering computers 2022. Cengage Learning.
14. Shelly, G.B., & Vermaat, C. (2018). Discovering computers: Digital technology, data, and devices. Cengage Learning.
15. Turban, E., & Wood, L. (2020). Introduction to information technology (3rd ed.). Wiley.
16. Long, L., & Long, N. (2019). Introduction to computers and information technology. Pearson.
17. O'Leary, T.J., & O'Leary, L.I. (2020). Computing essentials 2021 (29th ed.). McGraw-Hill Education.
18. Grauer, R.T., & Barber, M. (2021). Exploring Microsoft Office 2021 (Vol. 1). Pearson.
19. Fogler, H.S., & Gurmeet, S. (2019). Microsoft Office 2019: In practice. O'Reilly Media.
20. Walkenbach, J. (2022). Excel 2021 Bible. Wiley.

SEMESTER IV

I. MAJOR COURSE- MJ 5:
IKS: GEOTOURISM & GEOHERITAGE STUDIES

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

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

Course Objectives:

1. To introduce IKS principles of environmental conservation through the five elements and scriptural practices.
2. To explore ancient India's mineral technologies, geomythology, and contributions to geological sciences.
3. To examine traditional water management systems and their sustainable ecological applications.
4. To develop understanding of geoheritage, geotourism, and geological institutions' societal roles.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Explain the panchamahabhuta (five elements) framework, astronomical foundations, and IKS practices for environmental sustainability aligned with SDGs.
2. Describe ancient Indian mineral processing (e.g., medieval zinc smelting), geomythological traditions, and key geologists' contributions to nation-building.
3. Analyse traditional water conservation systems (baolis, johads, tanks) and apply IKS-derived sustainable practices to contemporary environmental challenges.
4. Identify major Indian geoheritage sites, evaluate geotourism potential, and articulate the societal roles of institutions like GSI and NGRI.

Course Content:

Unit 1: Introduction to IKS in environmental conservation; Formation, characteristics, and qualities of the five elements of Nature; Earth and Atmosphere; Astronomical foundation concepts of the solar system, and meteors; Environment components and related practices in scriptures; Current need of IKS for sustainability and sustainable development goals.

Unit 2: Early mining and use of minerals in ancient India; Introduction to geomythology: rocks, landforms, and folklore in Indian culture; Key contributions of renowned geologists; Role of geology in nation-building and resource mapping.

Unit 3: Minerals, metals, and chemistry in Ancient and Medieval India; Mineral Processing in 13th Century India; Medieval India's primacy in Zinc; Ore prospecting, smelting, and alloying techniques.

Unit 4: Traditional knowledge systems related to water management, stepwells (baolis), and check dams (johads), and tank irrigation, and ecological balance; Application of sustainable practices derived from ancient texts and practices; Integration of IKS in contemporary environmental conservation efforts.

Unit 5: Definition- Geoheritage; Importance and examples in India; Overview of major geoheritage sites; Introduction to geotourism and sustainable conservation; Major geological institutions in India (e.g., GSI, NGRI, IITs, universities) and their societal roles.

Reference Books:

1. Banerjee, N.R. (1985). Mining and metallurgy in ancient India. Archaeological Survey of India.
2. Biswas, A. K. (1985). Minerals and metals in pre-industrial India. Oxford & IBH Publishing. (Early mining, mineral chemistry, 13th-century processing, alloying techniques.)
3. Biswas, A.K. (1987). Mineral processing to elemental science in the medieval world: India and Europe. Asiatic Society of India.
4. Chandrasekharam, D. (2007). Geo-mythology of India. In Geology and religion (pp. 33-40). Geological Society of London. (Rocks, landforms, and folklore in Ramayana/Mahabharata geological processes.)
5. Chapple, C.K. (1998). Towards an indigenous Indian environmentalism. In E. Nelson & L. E. Nelson (Eds.), Purifying the earthly body of God: Religion and ecology in Hindu India (pp. 13-35). State University of New York Press.
6. Chattopadhyaya, D.P. (2014). Science and society in ancient India. K. P. Bagchi & Company.
7. Craddock, P. (2016). The early development of metallurgy in India and Pakistan. Maney Publishing. (Ancient Indian mining, medieval zinc smelting, ore processing techniques.)
8. Frawley, D. (2015). Tantra: The path of ecstasy. Lotus Press. (Five elements philosophy, panchamahabhuta characteristics, environmental balance.)
9. Jain, V. K. (2019). Traditional water harvesting systems in India. Aryan Books International. (Stepwells/baolis, johads, tank irrigation, ancient sustainable practices.)
10. Jha, A.K. (2020). Traditional knowledge system in India. Aryan Books International.
11. Kapoor, K., & Singh, A.K. (2005). Indian knowledge systems (Vol. 1). Indian Institute of Advanced Study; D. K. Printworld.

12. Mahadevan, B., Nagaswamy, R., & Ramaswami, S. (2022). Introduction to Indian knowledge system: Concepts and applications. PHI Learning Pvt. Ltd.
13. Rangarajan, L. N. (Ed.). (1992). The Arthashastra (3rd ed.). Penguin Classics. (Ancient water management, mining regulations, environmental conservation practices.)
14. Sharma, S. K., & Sharma, M. (2022). Indian knowledge systems: Traditions and sustainability. Bharatiya Kala Prakashan. (IKS environmental conservation, sacred groves, traditional ecological knowledge.)
15. Valdiya, K. S. (2016). Geoheritage and geotourism of India. The Energy and Resources Institute (TERI). (Major geoheritage sites, GSI/NGRI roles, sustainable geotourism.)

II. MAJOR COURSE- MJ 6:
FUNDAMENTALS OF PETROLOGY

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

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

Course Objectives:

1. To elucidate magma generation, crystallization processes, and igneous rock classification systems.
2. To examine mineralogical and petrographic characteristics of common igneous rocks and phase equilibria.
3. To explore sedimentary processes, diagenesis, and classification of clastic/carbonate rocks.
4. To analyse metamorphism agents, facies, and textural evolution of key metamorphic rocks.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Explain Bowen's reaction principle, IUGS classification, and magmatic differentiation processes including assimilation and emplacement styles.
2. Describe petrographic features of major igneous rocks (granite, basalt, gabbro, etc.) and interpret phase diagrams (albite-anorthite, Qz-Di-Ab systems).
3. Classify sedimentary rocks by texture/structure and identify key siliciclastic/carbonate types (conglomerate, limestone, shale).
4. Identify metamorphic grades, facies, index minerals/isograds, and describe characteristic rocks (gneiss, marble, quartzite) with textural analysis.

Course Content:

Unit 1: Magma: Definition, types and composition, causes of melting, magma crystallization, Bowen's reaction principle. Magma emplacement: Volcanic, Hypabyssal and plutonic, Magma Diversification: Magmatic differentiation and Assimilaiton, Texture and structures of Igneous rocks, Classification of Igneous rocks; IUGS Classification.

Unit 2: Mineralogical characteristics of basic and acidic rocks, Petrographic description of common Igneous rocks (Granite, Diorite, Syenite, Gabbro, Dolerite, Basalt, Rhyolite, Trachyte, Peridotite), Phase Rule; One component crystallization of Silica polymorphs, Bi-components crystallization of Albite-Anorthite system and Tri-component crystallization of Albite-Diopside-Anorthite system.

Unit 3: Processes of formation of sedimentary rocks, diagenesis and lithification, Basic idea of Texture and structures of sedimentary rocks

Unit 4: Classification of Clastic and non-clastic rocks, Petrographic description of important siliciclastic and carbonate rocks (Conglomerate, Breccia, Sandstone, Greywacke, Shale, Limestone)

Unit 5: Metamorphism: Definition, agents, types; Grades and Zones of metamorphism; Processes of metamorphism,

Unit 6: Classification of Metamorphic rocks; Textures and structures of metamorphic rocks; Concept and Classification of metamorphic facies; Index Minerals and Isograds, Metasomatism and its types. Petrographic description of important metamorphic rocks (Slate, phyllite, gneiss, hornfels, marble, quartzite)

Reference Books:

1. Best, M.G. (2004). Igneous and Metamorphic Petrology, CBS Publication.
2. Blatt, H., Middleton, G.V., Murray, R.C. (1980). Origin of Sedimentary Rocks, Prentice Hall-Inc.
3. Bose, M.K. (1997). Igneous Petrology, World Press, Kolkata.
4. Faure, G. (2001). Origin of Igneous Rocks, Springer.
5. Pettijohn, F. (2004) Sedimentary Rocks, 3rd Edition. CBS Publishers.
6. Philpotts, A.R. (1994) Principles of Igneous and Metamorphic Petrology. Prentice Hall of India.
7. Selley, R.C. (2000) Applied Sedimentology, Academic Press.
8. Turner, E.J. (1980). Metamorphic Petrology, McGraw Hill, NY.
9. Winter, J.D. (2001). An introduction to Igneous and Metamorphic Petrology, Prentice Hall, New Jersey
10. Yardley, B.W.D., Mackenzie, W.S., Guilford, C. (1995). Atlas of Metamorphic Rocks and their textures. Longman Scientific and Technical, England.

III. MAJOR COURSE- MJ 7:
PRACTICAL-II

Marks: Pr (ESE: 6Hrs) =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 6Hrs 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. Plotting of Geoheritage and Geoarchaeological sites of India.
2. Megascopic study of Igneous, Sedimentary and Metamorphic rocks.
3. Microscopic study of Igneous, Sedimentary and Metamorphic rocks.
4. To mark the important geoheritage sites on the Indian Map and their significance.
5. Locating the major Geological Institute of India on the map, along with its role and contribution.

Field Work

1. Geological mapping of one week duration in a geologically complex area and field work report based on it.

Reference Books:

1. Geological Society of India. (2023). Memoirs on Indian geology (Vol. 100+ series). Geological Society of India.
2. Geological Survey of India. (2001). National geological monuments of India (Special Publication No. 61). GSI.
3. Raith, M., Raase, P., & Reinhardt, J. (2012). Guide to thin section microscopy. Mineralogical Society of America. http://www.minsocam.org/msa/OpenAccess_publications/Guide_Thin_Sctn_Mcrscpy/Thin_Sctn_Mcrscpy_2_prnt_eng.pdf
4. Raymond, L.A. (2017). Petrography: A lab manual (Hands-specimen and thin-section study, 2nd ed.). Waveland Press.
5. Sen, A.K. (1995). Laboratory manual of geology. Modern Book Agency Private Ltd.
6. Valdiya, K.S. (2016). Geoheritage and geotourism of India. The Energy and Resources Institute (TERI).

SEMESTER V

I. MAJOR COURSE- MJ 8:
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:

1. To examine the interface between geology and civil engineering for structural planning and construction.
2. To analyse engineering properties of rocks, soils, and rock masses with classification systems.
3. To investigate geological hazards (landslides, earthquakes) and mitigation strategies.
4. To study site-specific geological considerations for tunnels, dams, and roads in diverse terrains.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Evaluate intact rock/rock mass properties, foundation treatments (grouting, bolting), and aggregates for construction suitability.
2. Classify soils using Unified Soil Classification System and recommend mitigation for landslides/earthquakes based on causal factors.
3. Apply rock mass classification systems (RQD, RMR, Q, GSI, RSR) to assess tunnel and dam site stability.
4. Design geological investigations and mitigation strategies for tunnels (NATM, TBM), dams, and roads in hilly, marshy, or permafrost regions with case study analysis.

Course Content:

Unit 1: Geology vs civil engineering, Role of engineering geologist in planning, design and construction of major man-made structural features, Engineering properties of rock; Intact Rock and Rock Mass properties, Rock aggregates and their significance as construction material, Foundation treatment; Grouting, rock bolting and other support mechanisms.

Unit 2: Physical and engineering properties of soil, Unified soil classification, Landslide: Types, Causes, Factor and Mitigation Strategies; Earthquake: Types, Causes, Factor and corrective/preventive measures.

Unit 3: Concept, Mechanism and Significance of Rock Quality Designation (RQD), Concept, Mechanism and Significance of Rock Structure Rating (RSR), Concept, Mechanism and Significance of Rock Mass Rating (RMR), Concept, Mechanism and Significance of Tunneling Quality Index (Q), Concept, Mechanism and Significance of Geological Strength Index (GSI)

Unit 4: Tunnels: Types, Feasibility & Design and Geological investigation of tunnel sites, Tunneling Methods: Fore poling method, Needle beam method, Belgian method, Heading and Bench method, Tunnel Boring Machine (TBM), NATM (New Austrian Tunneling Method), Hazards & Mitigation, Case Studies: Alpine tunnel projects, Indian tunnel projects (railway, road, hydropower).

Unit 5: Dam: Types, Forces acting on dam, geological consideration for Dam and Reservoirs; Geotechnical and environmental implications in the Dam construction. Geological considerations for the construction of Roads: Hilly regions, Marshy Regions, water logged areas and permafrost regions.

Reference Books:

1. Bell, F.G. (2007). Engineering Geology (2nd ed.). Butterworth-Heinemann.
2. Cruden, D.M., & Varnes, D.J. (1996). Landslide Types and Processes. National Academy Press.
3. Das, B.M. (2016). Principles of Foundation Engineering (8th ed.). Cengage Learning.
4. Gokhale, K.V.G.K. (2023). Principles of Engineering Geology. B.S. Publications.
5. Johnson, R.B. & De Graff, J.V. (1988). Principles of Engineering Geology. John Wiley Publication,
6. Krynine, D.P., Judd, W.R. (2001). Principles of Engineering Geology and Geotectonics. CBS Publications and Distributors.
7. Waltham, A.C. (2002). Foundations of Engineering Geology (3rd ed.). Spon Press.

II. MAJOR COURSE- MJ 9:
ECONOMIC AND MINING 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:

1. To introduce ore deposit concepts, mineral paragenesis, and classification of strategic minerals.
2. To examine major ore-forming processes and their geological controls.
3. To analyze economically important minerals, their Indian occurrences, and industrial applications.
4. To study surface/underground mining techniques, hazards, and safety protocols.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Define ore tenor, paragenetic sequences, zoning patterns, and classify strategic/critical minerals (metallic/non-metallic) with common deposit forms/structures.
2. Explain ore genesis processes including magmatic segregation, hydrothermal systems, supergene enrichment, and residual concentration mechanisms.
3. Describe geological occurrences, uses, and Indian distributions of key ores (chromite, iron, copper-Pb-Zn, coal, atomic fuels) and industrial minerals (refractories, cement, gems).
4. Compare mining methods (placer, open pit, underground, ocean floor) and recommend safety measures for common mining hazards.

Course Content:

Unit 1: Concept of ore, ore minerals and gangue in economic geology; Tenor of ores; Ore forming minerals –metallic and non-metallic; Common forms and structures of ore deposits; Paragenesis, paragenetic sequence and zoning in metallic ore deposits. Strategic, critical and essential minerals.

Unit 2: Processes of formation of ore deposits; Magmatic, contact metasomatic, pegmatitic, hydrothermal, sedimentation, residual concentration, mechanical concentration, oxidation and supergene sulphide enrichment and metamorphism.

Unit 3: Processes of formation, geological occurrence, uses and distribution in India: chromite, diamond, mica, iron, gold, copper-lead-zinc, manganese, bauxite, coal and petroleum, atomic fuels.

Unit 4: Study of important industrial minerals of India: minerals used in refractory, fertilizer, ceramic, cement, glass, paint industries; abrasive, building stones, gemstones.

Unit 5: Mining of surface and underground mineral deposits: Placer mining methods, open pit methods, Underground mining methods, Coal Mining methods and Ocean bottom mining methods. Mining hazards and safety measures.

Reference Books:

1. Arogyaswami, R.P.N. (1996) Courses in Mining Geology, IV Ed. Oxford IBH
2. Clark, G.B. (1967) Elements of Mining, III ed. John Wiley
3. Evans, A. M. (1993). Ore geology and industrial minerals: An introduction (3rd ed.). Blackwell Scientific Publications.
4. Gokhale, K.V.G.K., & Rao, T.C. (2005). Ore deposits of India: Their distribution and processing (3rd ed.). Himalaya Publishing House.
5. Hazarika, R.R., & Mishra, B. (2021). Economic geology: Principles and practices. Capital Publishing Company.
6. Iyengar, S.V.P. (1984). Coal resources of India. Geological Survey of India.
7. Prasad, U. (1996) Economic Geology, CBS Publisher and Distributor.
8. Robb, L. (2005). Introduction to ore-forming processes. Blackwell Publishing.
9. SME. (2011). SME mining engineering handbook (3rd ed., Ed. by P. Darling). Society for Mining, Metallurgy, and Exploration.

III. MAJOR COURSE- MJ 10:
GEOCHEMISTRY AND ISOTOPE 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:

1. To introduce fundamental geochemical concepts, elemental abundances, and Earth's differentiation.
2. To examine geochemical reservoirs, element partitioning, and mobility in geological systems.
3. To analyze geochemical processes, REE patterns, and isotopic systems for Earth system studies.
4. To explore thermodynamic principles and global geochemical cycles influencing mineral stability.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Explain Goldschmidt's classification, cosmic abundances, major/trace element significance, and geochemical differentiation of Earth layers.
2. Describe geochemical reservoirs and factors controlling element mobility (ionic potential, redox, P-T conditions) across mantle-crust-hydrosphere systems.
3. Interpret geochemical anomalies, REE patterns, HFSE/LILE behaviors, and apply radiogenic (U-Pb, Rb-Sr, Sm-Nd) and stable isotope systems for dating and paleoenvironmental reconstruction.
4. Apply thermodynamic principles (Gibbs free energy, chemical equilibrium) to analyze mineral stability and global cycles of C, O, S, N in Earth's evolution.

Course Content:

Unit 1: Fundamentals of Geochemistry and Elemental Distribution

Definition, scope, and significance of geochemistry; Cosmic abundance of elements; Structure and composition of the Earth: core, mantle, and crust; Goldschmidt's geochemical classification of elements; Major, minor, and trace elements and their geological significance; Geochemical differentiation of the Earth.

Unit 2: Geochemical Reservoirs and Element Mobility

Concept of geochemical reservoirs: mantle, crust, hydrosphere, atmosphere, biosphere. Element partitioning and redistribution; Element mobility and controlling factors (ionic potential, redox conditions, P–T effects).

Unit 3: Geochemical Processes in Earth Systems

Compatible and incompatible minerals; High Field Strength Elements (HFSE) and Large Ion Lithophile Elements (LILE); Significance of Rare Earth Elements (REE); geochemical processes in magmatic, sedimentary, and metamorphic systems; Geochemical anomalies and their use in mineral exploration.

Unit 4: Isotope Geochemistry

Fundamentals of isotope geochemistry; Radiogenic isotopes and radioactive decay principles Decay schemes: U–Pb, Rb–Sr, and Sm–Nd; Principles, assumptions, and limitations of radiometric dating; the age of the Earth; Stable isotopes: nature, abundance, and fractionation; Applications of stable isotopes in Earth system studies.

Unit 5: Thermodynamics and Geochemical Cycles

Basic terminology, laws of thermodynamics and their geological relevance; Chemical equilibrium and Gibbs free energy; Thermodynamic control on mineral stability and reactions; Introduction to geochemical cycles; Global geochemical cycles of Carbon, Oxygen, Sulfur, and Nitrogen; Coupling of geochemical cycles with Earth's evolution.

Reference Books:

1. Albarde F. (2003). Geochemistry- Introduction. Cambridge University Press.
2. Bloss, F.D. (1971). Crystallography and Crystal Chemistry. Holt, Rinehart, and Winston, New York. Klein,
3. Riddle, C. (1993). Analysis of geological materials. Marcel Dekker Inc.
4. Easton, A.J. (1972). Chemical analysis of silicate rocks. Elsevier
5. Evans, R.C., (1964). Introduction to Crystal Chemistry. Cambridge Univ. Press
6. Faure, G. (1986). Stable Isotope Geochemistry. John Wiley & Sons.
7. Henderson, P. (1984). REE geochemistry. Elsevier.
8. Hoefs, J. (1980). Stable Isotope Geochemistry, Springer and Verlag.
9. Krauskopf, K.B. (1967). Introduction to Geochemistry. McGraw Hill.
10. Mason, B. & Moore, C.B. (1991). Introduction to Geochemistry, Wiley Eastern.
11. Rankama, K. & Sahama Th. G. (1950). Geochemistry. Univ. Chicago Press.
12. Rollinson, H.R. (1993). Using geochemical data: Evaluation, presentation, interpretation. Longman U.K.

IV. MAJOR COURSE- MJ 11:
PRACTICAL-III

Marks: Pr (ESE: 6Hrs) =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 6Hrs 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. Computation of index properties of rocks, computation of R.Q.D., R.S.R, R.M.R and "Q"
2. Megascopic study & identification of Ore Minerals.
3. Location of different mineral deposits in the outline map of India.
4. Computation of RQD, RSR, RMR, GSI and Q.
5. Plotting of Seismic zones of India
6. Plotting of Major Dam/ Reservoirs on outline map of India.

Reference Books:

1. Bureau of Indian Standards. (2016). IS 1893 (Part 1): 2016 - Criteria for earthquake resistant design of structures: General provisions and buildings.
2. Gokhale, K.V.G.K., & Rao, T.C. (2005). Ore deposits of India: Their distribution and processing (3rd ed.). Himalaya Publishing House.
3. Hoek, E., & Brown, E.T. (2019). Practical rock engineering. Rocscience Inc.
4. Ramasamy, S.M. (2006). Remote sensing in geomorphology and hazards. New India Publishing Agency.
5. Sen, A.K. (1995). Laboratory manual of geology. Modern Book Agency Private Ltd.
6. Sharma, S.B. (2010). Engineering geology (4th ed.). S. Chand Publishing.

SEMESTER VI

I. MAJOR COURSE- MJ 12: ENVIRONMENTAL 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:

1. To introduce the multidisciplinary scope of environmental studies and sustainability principles.
2. To examine ecosystem functions, natural resource management, and biodiversity conservation.
3. To analyze human impacts on environment through population growth and resource conflicts.
4. To develop awareness of environmental movements, ethics, and disaster management strategies.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Explain the multidisciplinary nature of environmental studies, ecosystem structure/function, and sustainable development concepts.
2. Analyze renewable/non-renewable resource issues (land degradation, water conflicts, deforestation from mining/dams) and their impacts on biodiversity hotspots.
3. Evaluate threats to India's biodiversity, conservation strategies (in-situ/ex-situ), and ecosystem services across biogeographic zones.
4. Assess human-environment interactions through case studies of environmental movements (Chipko, Silent Valley), disasters, and ethical frameworks for sustainability.

Course Content:

Unit 1: Introduction to Environmental Studies:
Multidisciplinary nature of environmental studies. Scope and importance of environmental studies. Concept of sustainability and sustainable development.

Unit 2: Ecosystems:
Concept of ecosystem. Structure and function of ecosystem. Energy flow in an ecosystem. Food chains, food webs and ecological succession

Case Studies of Ecosystems
Forest ecosystem, Grassland ecosystem, Desert ecosystem, Aquatic ecosystems: ponds, streams, lakes, rivers, oceans, estuaries.

Unit 3: Natural Resources – Renewable and Non-Renewable:
Land resources and land use change, Land degradation, soil erosion and desertification. Deforestation: causes and impacts due to mining and dam construction. Impacts on environment, forests, biodiversity and tribal populations. Water resources: use and over-exploitation of surface and groundwater. Floods, droughts and conflicts over water (international and inter-state). Energy resources: renewable and non-renewable sources. Alternate energy sources and growing energy needs. Case studies related to natural resources.

Unit 4: Biodiversity and Conservation:
Levels of biodiversity: genetic, species and ecosystem diversity, Biogeographic zones of India, Biodiversity patterns and global biodiversity hotspots. India as a mega-biodiversity nation, Endangered and endemic species of India. Threats to biodiversity: habitat loss, poaching, man–wildlife conflict, biological invasion. Conservation strategies: in-situ and ex-situ conservation. Ecosystem and biodiversity services: ecological, economic, social, ethical, aesthetic and informational values.

Unit 5: Human Communities and the Environment:
Human population growth and its impacts on environment, health and welfare, Resettlement and rehabilitation of project-affected persons (case studies), Disaster management: floods, earthquakes, cyclones and landslides, Environmental movements: Chipko Movement, Silent Valley Movement, Bishnois of Rajasthan, Environmental ethics: role of Indian and global religions and cultures. Environmental communication and public awareness. Case study: CNG vehicles in Delhi.

Reference Books:

1. Carson, R. (2002). Silent Spring. Houghton Mifflin Harcourt.
2. Gadgil, M., & Guha, R. (1993). This Fissured Land: An Ecological History of India. Univ. of California Press.
3. Gleeson, B. and Low, N. (eds.) (1999). Global Ethics and Environment, London, Routledge.

4. Gleick, P.H. (1993). Water in Crisis. Pacific Institute for Studies in Dev., Environment & Security. Stockholm Env. Institute, Oxford Univ. Press.
5. Grumbine, R. Edward, and Pandit, M.K. (2013). Threats from India's Himalaya dams. Science, 339: 36---37.
6. McCully, P. (1996). Rivers no more: the environmental effects of dams (pp. 29---64). Zed Books.
7. McNeill, John R. (2000). Something New Under the Sun: An Environmental History of the Twentieth Century.
8. Mukherjee, B. (2011): Fundamentals of Environmental Biology. Silverline Publications, Allahabad.
9. Odum, E.P., Odum, H.T. & Andrews, J. (1971). Fundamentals of Ecology. Philadelphia: Saunders.
10. Pepper, I.L., Gerba, C.P. & Brusseau, M.L. (2011). Environmental and Pollution Science. Academic Press.
11. Rao, M.N. & Datta, A.K. (1987). Waste Water Treatment. Oxford and IBH Publishing Co. Pvt. Ltd.
12. Raven, P.H., Hassenzahl, D.M. & Berg, L.R. (2012). Environment. 8th edition. John Wiley & Sons.
13. Raziuddin, M.., Mishra P.K. (2014). A Handbook of Environmental Studies, Akanaksha Publications, Ranchi.
14. Rosencranz, A., Divan, S., & Noble, M.L. (2001). Environmental law and policy in India. Tripathi 1992.
15. Sengupta, R. (2003). Ecology and economics: An approach to sustainable development. OUP.
16. Singh, J.S., Singh, S.P. and Gupta, S.R. (2014). Ecology, Environmental Science and Conservation. S. Chand Publishing, New Delhi.
17. Sodhi, N.S., Gibson, L. & Raven, P.H. (eds). (2013). Conservation Biology: Voices from the Tropics. John Wiley & Sons.
18. Thapar, V. (1998). Land of the Tiger: A Natural History of the Indian Subcontinent.
19. Warren, C.E. (1971). Biology and Water Pollution Control. WB Saunders.
20. Wilson, E.O. (2006). The Creation: An appeal to save life on earth. New York: Norton.
21. World Commission on Environment and Development. (1987). Our Common Future. Oxford University.

II. MAJOR COURSE- MJ 13:
FOSSIL FUEL

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

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

Course Objectives:

1. To introduce fossil fuel classification, global/Indian energy scenarios, and formation processes.
2. To examine coal geology including coalification, petrography, and Indian Gondwana/Tertiary coalfields.
3. To analyse petroleum systems, trap formation, and major Indian hydrocarbon basins.
4. To explore unconventional resources (CBM, shale gas, gas hydrates) and environmental mitigation strategies.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Compare fossil fuel types, explain carbon cycle linkages, and evaluate energy security challenges in India's geological context.
2. Describe coal rank/grade systems, maceral analysis, petrographic properties, and characterize Gondwana vs Tertiary Indian coalfields.
3. Construct petroleum system models identifying source/reservoir/cap rocks, trap types, and migration pathways in major Indian basins.
4. Assess unconventional resources (CBM, shale gas, UCG, gas hydrates) and recommend geological strategies for CCS, mine reclamation, and energy transition.

Course Content:

Unit 1: Introduction to Fossil Fuels & Energy Resources- Definition, classification, and types of fossil fuels; Global and Indian energy scenario; Origin of fossil fuels – biological and geological perspectives; Carbon cycle and fossil fuel formation; Distribution of fossil fuels in geological time; Non-renewable vs renewable energy resources; Role of fossil fuels in industrial development; Energy security and sustainability issues.

Unit 2: Coal Geology- Origin and evolution of coal; Peat formation and coalification processes; Coal rank and grade classification; Maceral groups and coal petrography; Physical, chemical, and mineralogical properties of coal; Indian coalfields – Gondwana and Tertiary.

Unit 3: Petroleum Geology-Origin of petroleum – biogenic and abiogenic theories; Source rocks, reservoir rocks, and cap rocks; Petroleum migration and accumulation; Types of petroleum traps – structural, stratigraphic, combination; Oil and gas reservoirs; Petroleum systems and basin analysis; Major petroleum basins of India; Offshore and onshore petroleum resources.

Unit 4: Natural Gas, Unconventional Fossil Fuels & Coalbed Methane-Natural gas – origin, composition, and classification; Conventional vs unconventional gas; Coalbed Methane (CBM) – origin, occurrence, and extraction; Shale gas; Gas hydrates – occurrence and significance; Underground Coal Gasification (UCG).

Unit 5: Environmental Impact & Energy Transition-Environmental impacts of fossil fuel extraction; Mine closure and reclamation; Carbon Capture and Storage (CCS); Role of geology in energy transition.

Reference Books:

1. Bustin, R.M., & Ross, H. (2019). Unconventional hydrocarbon resources. American Association of Petroleum Geologists.
2. Gluyas, J., & Swarbrick, R. (2004). Petroleum geoscience. Blackwell Publishing.
3. Hunt, J.M. (1996). Petroleum geochemistry and geology (2nd ed.). W.H. Freeman and Company.
4. Thomas, L.P. (2013). Coal geology (2nd ed.). John Wiley & Sons.
5. Tissot, B. P., & Welte, D.H. (1984). Petroleum formation and occurrence (2nd ed.). Springer-Verlag.
6. Tiwary, A. (2009). Coal and petroleum geology of India. Scientific Publishers (India).

III. MAJOR COURSE- MJ 14:
HYDROLOGY

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

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

Course Objectives:

1. To introduce hydrologic cycle fundamentals, aquifer properties, and groundwater occurrence.
2. To examine groundwater movement principles and well hydraulics for resource development.
3. To develop skills in groundwater exploration using geological, remote sensing, and geophysical methods.
4. To analyse groundwater quality, pollution, and management strategies in Indian hydrogeological provinces.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Explain the hydrologic cycle components, aquifer types (confined/unconfined), and properties (porosity, permeability, specific yield/retention) with groundwater classifications.
2. Apply Darcy's law to calculate hydraulic gradients and flow rates across porous, fractured, and karst aquifers, including steady/unsteady well hydraulics.
3. Design groundwater exploration programs using surface/sub-surface methods, VES profiling, and interpret pumping test data for aquifer parameters (T, S).
4. Evaluate groundwater chemistry (hydrochemical facies), pollution sources, artificial recharge techniques, and recommend management strategies per CGWB/GSI guidelines for Indian provinces.

Course Content:

Unit 1: Introduction and Hydrologic Cycle:
Definition, scope, and importance of hydrogeology, Origin and distribution of Earth's water, Hydrologic cycle: precipitation, infiltration, runoff, evapotranspiration, Porosity, permeability, specific yield, specific retention, Types of groundwater: vadose water, phreatic water, connate water, juvenile water.

Unit 2: Occurrence and Movement of Groundwater:
Aquifers: unconfined, confined, semi-confined, perched aquifers, Aquiclude, aquitard, aquifuge, Darcy's law and its applications, Hydraulic gradient and groundwater flow, Groundwater flow in porous, fractured, and karst media.

Unit 3: Well Hydraulics and Groundwater Development:
Types of wells: dug wells, tube wells, artesian wells, well construction methods, Cone of depression and radius of influence, Steady and unsteady state flow to wells, Specific capacity and well efficiency, Pumping tests and aquifer parameters (T, S).

Unit 4: Groundwater Exploration and Quality:
Surface and subsurface methods of groundwater exploration, Geological, geomorphological, and remote sensing techniques, Geophysical methods: electrical resistivity methods (VES, profiling), Groundwater chemistry: major ions and hydrochemical facies, Drinking water standards (BIS & WHO), Groundwater pollution: sources and types.

Unit 5: Groundwater Management and Indian Context:
Groundwater recharge and discharge, Artificial recharge techniques, Groundwater balance and safe yield, Over-exploitation and groundwater legislation in India, Hydrogeological provinces of India, Role of CGWB and GSI in groundwater studies.

Reference Books:

1. CGWB (Govt. of India). Groundwater Year Books and Reports.
2. Fetter, C.W. (2014). Applied Hydrogeology. Pearson.
3. Freeze, R.A. & Cherry, J.A. (1979). Groundwater. Prentice Hall.
4. Heath, R.C. (1983). Basic Ground-Water Hydrology. USGS.
5. Karanth, K.R. (2007). Groundwater Assessment, Development and Management. Tata McGraw-Hill.
6. Raghunath, H.M. (2006). Ground Water. New Age International.
7. Singhal, B.B.S. & Gupta, R.P. (2010). Applied Hydrogeology of Fractured Rocks. Springer.
8. Subramaniam, V. (2009). Hydrogeology. Oxford University Press.
9. Todd, D.K. & Mays, L.W. (2005). Groundwater Hydrology. Wiley.
10. Walton, W.C. (1970). Groundwater Resource Evaluation. McGraw-Hill.

IV. MAJOR COURSE- MJ 15:
PRACTICAL-IV

Marks: Pr (ESE: 6Hrs) =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 6Hrs 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. Calculation of hydrological properties: Porosity, Permeability, yield retention, Hydraulic gradient, and ground water flow, Transmissivity. Geophysical method, Resistivity, Piper diagram.
2. Study of hand specimen of coal.
3. Study of Geological Section coal and petroleum fields and identification of Hydrocarbon prospect
4. Distribution of seismic zone in India.

Field Geology:

Two-weeks field excursion.

Reference Books:

1. Bureau of Indian Standards. (2016). IS 1893 (Part 1): 2016 - Criteria for earthquake resistant design of structures.
2. Fetter, C.W. (2001). Applied hydrogeology (4th ed.). Prentice Hall.
3. Karanth, K.R. (1987). Groundwater assessment, development and management. Tata McGraw-Hill.
4. Sharma, S.B. (2010). Engineering geology (4th ed.). S. Chand Publishing.
5. Thomas, L.P. (2013). Coal geology (2nd ed.). John Wiley & Sons.
6. Todd, D.K., & Mays, L.W. (2005). Groundwater hydrology (3rd ed.). John Wiley & Sons.

SEMESTER VII

I. MAJOR COURSE- MJ 16:
RESEARCH METHODOLOGY

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

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

Course Objectives:

1. Establish foundational understanding of scientific research principles, design, and ethical responsibilities tailored to geological investigations.
2. Develop proficiency in data collection, statistical analysis, and geoscientific visualization techniques including GIS and remote sensing applications.
3. Equip learners with literature survey skills using academic databases and effective scientific communication strategies.
4. Foster advanced research capabilities in fieldwork, laboratory analysis, and professional writing for theses and funding proposals.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Formulate research problems, conduct literature reviews using Scopus/Web of Science, and design valid geological studies with appropriate sampling and statistical methods.
2. Collect and analyse primary/secondary geological data using basic statistics, graphical tools (stereonets, ternary plots), and software for correlation/regression.
3. Apply research ethics principles, recognize misconduct (plagiarism, falsification), and utilize reference management tools with APA/Harvard citation styles.
4. Execute geological fieldwork/mapping, apply GIS/remote sensing for spatial analysis, and prepare structured scientific reports, proposals, and presentations.

Course Content:

Unit 1: Foundations of Scientific Research

Science and technology: meaning, scope, and interrelationship; Nature, objectives, and types of scientific research; Characteristics of good research and research quality indicators; Scientific attitude, temperament, and responsibilities of a researcher; Research problems: identification, formulation, and validation; Overview of contributions of Indian scientists to global research.

Unit 2: Research Design, Literature Survey, and Communication

Research planning and design; Criteria of validity and reliability in research; Literature survey techniques: books, journals, conference proceedings; Use of electronic databases: Scopus, Web of Science, Google Scholar, PubMed; Reading and reviewing scientific papers; Scientific communication: seminars, conferences, and workshops.

Unit 3: Data Collection and Basic Statistical Techniques

Primary and secondary data sources in geology; Quantitative and qualitative data types; Basic statistics in geosciences: mean, median, mode, variance, standard deviation; Frequency distribution and probability concepts; Correlation and regression; Graphical representation: histograms, pie diagrams, ternary plots, rose diagrams, stereonets.

Unit 4: Research Ethics and Professional Practices

Research ethics: principles, values, and codes of conduct; Ethical issues in scientific research; Research misconduct: fabrication, falsification, plagiarism; Role of ethics committees and regulatory bodies; Authorship, conflicts of interest, and peer review ethics.

Unit 5: Research Methods and Analytical Techniques in Geosciences

Preparation for geological fieldwork and field documentation; Geological mapping in igneous, sedimentary, and metamorphic terrains; Sampling techniques for rocks, minerals, and fossils; Laboratory analytical procedures: rock and mineral analysis; Sedimentological techniques: grain size and shape analysis; Paleontological and micropaleontological methods.

Unit 6: Remote Sensing, GIS, and Scientific Writing

Role of Remote Sensing and GIS in Geological Research; Digital data handling and database creation; Spatial data analysis and thematic mapping using GIS; Remote sensing–based modelling and applications in geosciences; Structure of scientific reports, dissertations, and theses; Writing abstracts, research proposals, and funding applications; Reference management tools; Citation styles: APA, Harvard

Practical / Project Work

Framing a research question and writing a short proposal
Designing a sample questionnaire or data collection tool
Collecting mock data and presenting it using graphs or basic stats
Referencing using software like Zotero, Mendeley
Writing a mini-report based on collected data

Reference Books:

1. Chaddah, P. (2018). Ethics in competitive research: Do not get scooped; do not get plagiarized. Office of the Principal Scientific Adviser to the Government of India.
2. Crompton, W. (n.d.). Manual of field geology. [Publisher information unavailable].
3. Davis, J. C. (2002). Statistics and data analysis in geology (3rd ed.). Wiley.
4. Fink, A. (2010). Conducting research literature reviews: From the internet to paper (3rd ed.). Sage Publications.
5. Gupta, R.P. (2018). Remote sensing geology (3rd ed.). Springer.
6. Hofmann, M., & Tierney, B. (2019). Research design in geosciences. Elsevier.
7. Kothari, C.R. (2019). Research methodology: Methods and techniques (4th ed.). New Age International Publishers.
8. Kumar, R. (2005). Research methodology: A step-by-step guide for beginners (2nd ed.). Pearson Education.
9. Muralidhar, K., Ghosh, A., & Singhvi, A. K. (2019). Ethics in science education, research and governance. Indian National Science Academy.
10. Usham, A.L. (n.d.). Research methodology in geology. [Publisher information unavailable].

II. MAJOR COURSE- MJ 17:
ADVANCED 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:

1. To introduce crystal morphology, symmetry, and classification into crystal systems.
2. To explore crystal projections, structural chemistry, and stereographic representations.
3. To examine physical/chemical properties and structures of rock-forming silicate/non-silicate minerals.
4. To develop skills in optical mineralogy using petrological microscopes for mineral identification.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Describe crystal parameters, indices, symmetry elements, and classify crystals into the six systems (normal class).
2. Construct stereographic projections and explain crystal chemistry, including CCP/HCP structures.
3. Identify and characterize common rock-forming minerals by physical, chemical, and structural properties.
4. Use optical microscopy to recognize key minerals (e.g., olivine, pyroxene, amphibole, quartz, mica, feldspar) based on light properties and diagnostic features.

Course Content:

Unit 1: Elements of seismology– body and surface waves, propagation of body waves in the earth's interior; Radioactivity; Continental drift, seafloor spreading and convection current hypotheses; Geomagnetism and Palaeomagnetism, polar wandering and reversal of earth's magnetic field; Geomagnetic time scale; Principal Geotectonic features: Features of the Ocean, Continent and Continental margins.

Unit 2: Plates and plate boundaries; Principles of Plate Tectonics; Force Balance and Mantle Plume models of plate movements; Rift valleys, mid oceanic ridges, Island arcs; Orogeny and Epeirogeny; Anatomy of orogenic Belts; Structure and Origin of the Himalaya; Quaternary tectonics; Tectonic framework of India.

Unit 3: Mechanical principles; Properties of rocks and their controlling factors; Concept of Stress; Theories of Rock failure; Mohr circle and their representation for various states of stress; Mechanics of faulting; Anderson's theory of faulting and its limitations; Geometry of normal, strike-slip and thrust faults; Mechanics of folding and buckling; Ramsay's classification of folds; Superposed folding.

Unit 4: Concept of Strain; Types of strain ellipses and ellipsoids- their properties and geological significance; Strain markers and methods of strain measurements in naturally deformed rocks; Brittle and ductile shear zones; Shear zone rocks: cataclasite, breccia, mylonite, pseudo tachylyte; Shear sense indicators.

Unit 5: Cleavage, Schistosity and Lineation – their description, origin and relation to major structures. Petro fabric analysis– Petro fabric diagrams and their interpretation. Classification and characteristics of Tectonites, Diapirs and related structural features.

Reference Books:

1. Condie, K.C. (1982). Plate Tectonics and Crustal Evolution. Pergamon Press, New York.
2. Davis, G.H., & Reynolds, S.J. (2011). Structural Geology of Rocks and Regions (3rd ed.). John Wiley & Sons, New York.
3. Fossen, H. (2010). Structural Geology. Cambridge University Press, Cambridge.
4. George, H.D. (2011). Structural Geology of Rocks and Regions, John Wiley and Sons.
5. Ghosh, S.K. (1993). Structural Geology: Fundamentals and Modern Developments. Pergamon Press, Oxford.
6. Hobbs, B.E., Means, W.D., & Williams, P.F. (1976). An Outline of Structural Geology. John Wiley & Sons, New York.
7. Naqvi, S.M. (2005). Geology and Evolution of the Indian Plate (From Hadean to Holocene - 4Ga to 4 Ka) GSI, Bangalore.
8. Price, N.J., & Cosgrove, J.W. (1990). Analysis of Geological Structures. Cambridge University Press, Cambridge.
9. Ramsay, J.G. (1967). Folding and Fracturing of Rocks. McGraw-Hill, New York.
10. Whitten, E.H.T. (1966). Structural Geology of Folded Rocks. Rand McNally, Chicago.
11. Windley, B.F. (1973). The Evolving Continents. John Wiley & Sons, New York.

III. MAJOR COURSE- MJ 18:
PRACTICAL-V

Marks: Pr (ESE: 6Hrs) =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 6Hrs 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. Preparation and interpretation of Geological maps and sections
2. Structural problems based on orthographic and stereographic projections
3. Recording and plotting of the field data
4. Study of the hand specimen of deformed structures.

Reference Books:

1. Billings, M.P. (1972). Structural geology (3rd ed.). Prentice-Hall.
2. Davis, G.H., & Reynolds, S.J. (1996). Structural geology of rocks and regions (2nd ed.). John Wiley & Sons.
3. Fossen, H. (2016). Structural geology (2nd ed.). Cambridge University Press.
4. Geological Survey of India. (2015). Geological mapping manual. GSI Training Publication.
5. Ragan, D.M. (2009). Structural geology: An introduction to geometrical techniques (4th ed.). Cambridge University Press.
6. Sen, A.K. (1995). Laboratory manual of geology. Modern Book Agency Private Ltd.

IV. ADVANCED MAJOR COURSE- AMJ 1: GEOMORPHOLOGY AND RS-GIS

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

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

(Only for Hons Degree)

Course Objectives:

1. To introduce endogenic-exogenic processes shaping Indian landforms and long-term landscape evolution.
2. To examine surficial processes, drainage analysis, and geomorphic applications in resource exploration.
3. To develop skills in photogeology, remote sensing, and digital image processing techniques.
4. To apply GIS, GPS, and terrain analysis for geomorphological mapping and strategic evaluations.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Analyze endogenic-exogenic interactions, Himalayan topography, drainage development, and eustatic influences on Indian geomorphic evolution.
2. Identify weathering, glacial, fluvial, aeolian, and coastal landforms; interpret drainage patterns for groundwater/mineral exploration applications. Interpret aerial photographs for rock type identification and landform recognition across sedimentary, igneous, and metamorphic terrains.
3. Process satellite imagery (FCC, ratioing, classification), integrate RS-GIS-GPS data, and perform morphometric analysis for terrain evaluation and geomorphic mapping.

Course Content:

Unit 1: Introduction to Geomorphology, Overview of Indian Geomorphology. Endogenic and Exogenic processes, Endogenic- Exogenic interactions, Rates of uplift and denudation, Tectonics and drainage development, Sea-level change, 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). Evidence of eustatic changes and their causes. Influence of lithology on relief. Development of landforms of flat-lying, tilted, folded, dome and faulted structures.

Unit 2: 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, 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: Photogeology: Types and acquisition of aerial photographs, 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. Application of remote sensing in mineral exploration, groundwater exploration and geomorphology.

Unit 5: Digital Image Processing: Fundamentals of Image processing, Image Correction, Image enhancement, Image classification, F.C.C. and Image Rationing, 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. Integration of RS with GIS. Principles of terrain analysis, Morphometric analysis, Geomorphological mapping based on the genesis of landforms; Terrain evaluation for strategic purposes.

Reference Books:

1. Richard, J.H. (2007). Fundamentals of Geomorphology, Routledge.
2. Thornbury, W.D. (1969). Principles of Geomorphology, Wiley.
3. Worcester, P.G. (1948) A text book of Geomorphology.
4. Sparles, B.W. (1981). Geomorphology, Longman Group Ltd.
5. Bloom, A.L. (1979). Geomorphology, Prentice Hall.
6. Arthur, L.B. (2004) Geomorphology: a systematic analysis of late Cenozoic landforms, Waveland Pr Inc.
7. Miller, V.C (1961). Photogeology; McGraw Hill
8. Sabbins, F.F. (1985). Remote Sensing-Principles and Applications; Freema
9. Lillesand, T.M. & Keifer, R.W. (1987). Remote Sensing and Image Interpretation; John Wiley
10. Pandey, S.N. (1987). Principles and Applications of Photogeology; Wiley Eastern, New Delhi
11. Gupta, R.P. (1990). Remote Sensing Geology; Springer Verlag

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OR

RESEARCH COURSES- RC 1: (In lieu of AMJ 1)

RESEARCH PLANNING & TECHNIQUES

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

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

(Only for Hons with Research Degree)

Course Objectives:

1. Introduce fundamental research concepts, scientific methods, and research design principles for problem formulation and planning in geological studies.
2. Develop skills in data collection, statistical analysis, and research tools including GIS and software applications relevant to earth sciences.
3. Instil ethical research practices, IPR awareness, and plagiarism prevention aligned with UGC regulations.
4. Equip learners with scientific writing, communication, and evaluation techniques for proposals, theses, and peer-reviewed publications.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Formulate research problems, hypotheses, and designs using appropriate sampling and literature review techniques for field-based geological investigations.
2. Collect, organize, and analyse qualitative/quantitative data using basic statistics, Excel, and visualization tools while addressing errors and uncertainties.
3. Apply research ethics, IPR principles, and digital tools (GIS, remote sensing) to conduct responsible scientific inquiry.
4. Prepare structured research proposals, reports, and presentations following APA/Harvard styles, including abstracts and peer-review processes.

Course Content:

Unit 1: Introduction to Research and Scientific Method:

Meaning, objectives, and scope of research, Types of research: basic, applied, exploratory, descriptive, analytical, Scientific method: observation, hypothesis, experimentation, interpretation, Inductive and deductive reasoning, Role of research in science, society, and national development

Unit 2: Research Design and Planning:

Selection and formulation of research problems, Review of literature: sources, databases, and techniques, Research questions and hypothesis formulation, Research design: experimental, survey, case study, field-based studies, Sampling methods and sample size determination

Unit 3: Data Collection, Analysis and Statistics:

Types of data: qualitative and quantitative, Methods of data collection: field, laboratory, secondary data, Data organisation and presentation: tables, graphs, charts, Basic statistics: mean, median, mode, variance, standard deviation, Correlation and regression concepts, Error analysis and uncertainty

Unit 4: Research Tools, Techniques and Ethics:

Laboratory and field-based research tools, Basics of instrumentation and analytical techniques (overview), Use of computers in research: MS Excel, statistical software (introductory), Remote sensing, GIS, and digital databases (introductory), Research ethics: plagiarism, fabrication, falsification, Intellectual Property Rights (IPR) and copyright

Unit 5: Scientific Writing, Communication and Evaluation:

Structure of research proposals and reports, Thesis, dissertation, and project report formats, Referencing and citation styles (APA, Harvard, Chicago), Abstract writing, keywords, and summaries, Oral and poster presentations, Peer review process and impact metrics (h-index, impact factor)

Unit 6: Project Work and Practical Application

Mini project on a chosen research topic; Preparing a report and delivering a presentation; Peer review and feedback

Reference Books:

1. Ahuja, R. (n.d.). Research methods. Rawat Publications.
2. Breakwell, G.M., Hammond, S., Fife-Schaw, C., & Smith, J. A. (Eds.). (n.d.). Research methods in psychology. Sage.
3. Cohen, L., Manion, L., & Morrison, K. (2018). Research methods in education (8th ed.). Routledge.
4. Creswell, J.W. (2014). Research design: Qualitative, quantitative, and mixed methods approach (4th ed.). Sage Publications.
5. Day, R.A., & Gastel, B. (2012). How to write and publish a scientific paper (7th ed.). Cambridge University Press.
6. Garg, B.L., Karadia, R., Agarwal, F., & Agarwal, U.K. (2014). An introduction to research methodology. RBSA Publishers.

7. Kerlinger, F.N., & Lee, H. B. (n.d.). Foundations of behavioral research (4th ed.). Holt, Rinehart and Winston.
8. Kothari, C.R., & Garg, G. (2019). Research methodology: Methods and techniques (4th ed.). New Age International.
9. Montgomery, D.C., & Runger, G.C. (2011). Applied statistics and probability for engineers (5th ed.). Wiley.
10. Trochim, W.M.K. (2006). Research methods: The essential knowledge base. Cengage Learning.
11. University Grants Commission. (2018). UGC (Promotion of academic integrity and prevention of plagiarism in higher educational institutions) regulations, 2018. Gazette of India.

SEMESTER VIII

I. MAJOR COURSE- MJ 19:
ADVANCED PETROLOGY

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

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

Course Objectives:

1. To elucidate magma origins, classification schemes, and petrogenesis of major igneous rock suites.
2. To examine sedimentary processes, environments, provenance analysis, and Indian basin evolution.
3. To analyse metamorphic facies, mineral phase relations, and fabric development in diverse terrains.
4. To integrate plate tectonics with petrological processes across igneous, sedimentary, and metamorphic domains.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Apply IUGS/TAS classifications, interpret phase equilibria, and explain petrogenesis of Indian igneous suites.
2. Analyse sedimentary provenance/maturity, classify clastic/non-clastic rocks, construct facies models, and evaluate Indian sedimentary basins using seismic/sequence stratigraphy.
3. Construct ACF/AKF/AKFM diagrams, identify and describe mineralogical evolution across grade zones.
4. Correlate regional metamorphism patterns with plate tectonics, including Archean-Proterozoic terrain development and ocean floor metamorphism.

Course Content:

Unit 1: Magma: Nature, origin, types and physical properties, association with Plate tectonics, magmatism, Large Igneous Province (LIP) and mafic dyke swarms, Partial melting, Bases of Classification of Igneous rocks.

Unit 2: Norm and mode, Classification scheme: Niggli, Hatch and Wells, IUGS, TAS Diagram, Phase equilibrium – Binary system, ternary system and their relation to magma genesis and crystallization. Petrology and petrogenesis of major igneous rock types with Indian examples of ultramafic rocks, granitoids, kimberlite, basalt, komatiite, granite, alkaline rocks, carbonatites, lamprophyres, ophiolites.

Unit 3: Physical and chemical weathering, soil formation, sediment production and transport by wind, water and ice, Process of deposition, primary and secondary structures, Classification of Sedimentary rocks, Clastic and non-clastic rocks, Provenance, compositional maturity, light and heavy mineral analysis.

Unit 4: Sedimentary environments and facies, Facies models, Tectonics and sedimentation, cyclic sediments, Sedimentary basins of India, Basin analysis, Seismic and sequence stratigraphy.

Unit 5: Concept of grade and zone, mineralogical phase rule, metamorphic facies with detail description of each of low pressure, medium to high pressure and very high pressure, Metamorphic facies series, fabrics in metamorphism, Differentiation, ACF, AKF and AKFM diagrams.

Unit 6: Regional and ocean floor metamorphism, Regional and thermal metamorphism of Pelitic rocks, Basic rocks, Ultrabasic rocks, impure siliceous carbonate rocks, Metamorphism of Granitoids, Charnockite and Migmatite, Plate tectonics and metamorphic processes, Paired metamorphic belts, Archean and Proterozoic Terrain.

Reference Books:

1. Best, M.G. (2004). Igneous and Metamorphic Petrology, CBS Publication.
2. Blatt, H., Middleton, G.V., Murray, R.C. (1980). Origin of Sedimentary Rocks, Prentice Hall-Inc.
3. Bose, M.K. (1997). Igneous Petrology, World Press, Kolkata.
4. Pettijohn, F. (2004) Sedimentary Rocks, 3rd Edition. CBS Publishers.
5. Philpotts, A.R. (1994) Principles of Igneous and Metamorphic Petrology. Prentice Hall of India.
6. Selley, R.C. (2000) Applied Sedimentology, Academic Press.
7. Turner, E.J. (1980). Metamorphic Petrology, McGraw Hill, NY.
8. Winter, J.D. (2001). An introduction to Igneous and Metamorphic Petrology, Prentice Hall, New Jersey
9. Yardley, B.W.D., Mackenzie, W.S., Guilford, C. (1995). Atlas of Metamorphic Rocks and their textures. Longman Scientific and Technical, England.

II. MAJOR COURSE- MJ 20:
PRACTICAL-VI

Marks: Pr (ESE: 6Hrs) =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 6Hrs 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 and Microscopic studies of Igneous, Sedimentary and Metamorphic rocks.
2. Megascopic studies of Sedimentary structures.
3. Graphic representation of Modal analyses in QAP and APF diagrams
4. Graphic representation of chemical analyses in ACF, AKF and AFM diagrams.
5. Calculation of C.I.P.W. Normand Niggli Values.

Reference Book:

1. Deer, W.A., Howie, R.A., & Zussman, J. (2013). Rock-forming minerals (5th ed., Vols. 1A–4B). The Geological Society.
2. Le Bas, M.J., Le Maitre, R.W., Streckeisen, A., & Zanettin, B. (1986). A chemical classification of volcanic rocks based on the total alkali–silica diagram. Journal of Petrology, 27(3), 745–750.
3. Nesse, W.D. (2013). Petrography: An introduction to the study of rocks in thin section (4th ed.). W.H. Freeman and Company.
4. Philpotts, A.R., & Ague, J.J. (2009). Principles of igneous and metamorphic petrology (2nd ed.). Cambridge University Press.
5. Sen, A.K. (1995). Laboratory manual of geology. Modern Book Agency Private Ltd.
6. Yardley, B.W.D., MacKenzie, W. S., & Guilford, C. (1997). Atlas of metamorphic rocks and textures. Longman.

III. ADVANCED MAJOR COURSE- AMJ 2: OCEANOGRAPHY AND CLIMATOLOGY

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

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

(Only for Hons Degree)

Course Objectives:

1. To introduce ocean basin structure, physical/chemical properties, and marine geological processes.
2. To examine ocean circulation dynamics, atmospheric interactions, and Indian monsoon mechanisms.
3. To analyze global climate systems, palaeoclimatology, and environmental hazard assessment.
4. To develop skills in oceanographic instrumentation, remote sensing, and sustainable ocean management.

Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. Describe ocean basin evolution through plate tectonics, hypsometric patterns, marine sediments, and scientific drilling achievements.
2. Explain seawater properties (thermocline, salinity, density), circulation patterns (Ekman spiral, ENSO), tides/waves, and air-sea interactions driving Indian monsoons.
3. Analyze climate drivers (Hadley cells, greenhouse effect), palaeoclimate proxies, and hazards (cyclones, tsunamis, SLR) with mitigation strategies.
4. Apply remote sensing, CTD profiling, and oceanographic modeling to assess climate change impacts (ocean acidification, conservation policies).

Course Content:

Unit 1: Fundamentals of Oceanography:
Introduction to oceanography: scope, history, and modern developments, Structure and properties of the ocean basins, hypsometric curves, Plate tectonics and evolution of ocean basins, submarine topography, Scientific Ocean drilling, sediment sampling, marine sediments (type and distribution), Major achievements and applications of oceanographic research.

Unit 2: Physical and Chemical Oceanography:
Physical properties of seawater: temperature, salinity, density and their distribution, Thermocline, pycnocline, halocline, and mixed layers; ocean stratification, Ocean circulation: surface and deep currents, Coriolis force, Ekman spiral, El Niño/La Niña, Sea waves, tides: origin, types, prediction and their importance, Chemical composition of seawater, trace elements, major ion cycles, dissolved gases (O_2, CO_2), and nutrient cycling.

Unit 3: Marine Meteorology and Climatology Basics
Composition and structure of Earth's atmosphere, Energy balance: insolation, heat transfer, terrestrial radiation, Formation and classification of clouds, types of precipitation, Air-sea interactions, monsoons, and climate zones; weather forecasting methods, Weather systems: air masses, fronts, cyclones and anticyclones, thunderstorms; Indian monsoon: origin, mechanism, variability, impacts, features and variability, Basics of synoptic meteorology and climate classification (Köppen, Thornthwaite).

Unit 4: Applied Oceanography & Climatology:
Greenhouse effect, ozone layer, and atmospheric chemistry, Atmospheric moisture, condensation, precipitation processes, stability and instability, Climate change drivers (natural and anthropogenic); palaeoclimatology and proxies, Global climate systems: Hadley and Walker cells, ENSO, IOD, their impact on Indian and world climate, Climate hazards: droughts, floods, heat/cold waves, and marine hazards; Coastal Hazards: cyclones, storm surges, sea level rise, tsunami preparedness, Environmental issues: global warming impacts on oceans and climate, marine conservation, international conventions.

Unit 5: Techniques in Oceanography & Climatology:
Remote sensing and satellite applications in oceanography and climatology, Modern instrumentation: CTD, moorings, floats, marine data collection, Oceanographic and meteorological modeling basics, Ocean-atmosphere feedbacks, impacts of climate change on oceans (acidification, warming, SLR), Conservation, policies (UNCLOS, IPCC reports), sustainable management of ocean and climate resources.

Recommended readings

1. Asnani, G.C. (1993) Tropical Meteorology, Noble Printers Pvt. Ltd., India
2. Gross, M.G. (1996). Oceanography: A View of the Earth, Upper Saddle River, N.J.: Prentice Hall
3. Kennett, J.P. (1982). Marine Geology, Englewood Cliffs, N.J.: Prentice-Hall
4. Knauss, J. A. (1996). Introduction to physical oceanography, 2nd edition, 1996, Prentice Hall, Upper Saddle River, New Jersey.

5. Lal, D.S. (2010). Climatology, Sharda Pustak Bhavan, Prayagraj,
6. Marshall, J., Plumb, R.A. (2008). Atmosphere, Ocean, and Climate Dynamics, Academic Press, Elsevier.
7. Sverdrup, H.U., Johnson, M.W., Fleming, R. H. (1942). The Oceans: Their Physics, Chemistry and General Biology, Prentice Hall, Inc., New York.
8. Talley, L., Pickard, G.L., Emery W.J., Swift, J. (2011). Descriptive Physical Oceanography: an introduction. Academic Press
9. Tomczak, M, Godfrey, J. S. (2002). Physical Oceanography.
10. Wallace, J.M., Hobbs, P.V. (2006). Atmospheric Science: An Introductory Survey, Elsevier.

IV. ADVANCED MAJOR COURSE- AMJ 3:
PRACTICAL-VII (OCEANOGRAPHY AND CLIMATOLOGY)

Marks: Pr (ESE: 6Hrs) =100	**Pass Marks: Pr (ESE) = 40**

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

(Only for Hons Degree)

Instruction to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs 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. Ocean floor topography from contour maps
   Interpretation of bathymetric charts, hypsometric curve plotting, mid-ocean ridge/trench identification.
2. Marine sediment classification
   Grain size analysis using sieves, classification (terrigenous/biogenous) from sand samples.
3. Seawater density stratification
   Colored saltwater density columns (sugar/salt solutions), thermocline/pycnocline demonstration.
4. Tide curve analysis
   Manual plotting of tidal data from tide tables, diurnal/semidiurnal tide identification.
5. Simple seawater chemistry
   pH testing (universal indicator paper), dissolved salt measurement (evaporation method).
6. Köppen climate classification
   Manual mapping of Indian climate zones using printed temperature/rainfall data.
7. Monsoon rainfall variability
   Graph plotting of IMD rainfall data, break monsoon identification.
8. ENSO impact analysis
   Correlation charts: Indian rainfall vs NINO 3.4 index from printed datasets.
9. Satellite image interpretation
   Land-sat/IRS images: coastal features, ocean color analysis (printed hardcopies).
10. Air-sea heat budget calculation
    Manual computation using insolation tables and temperature data.

Reference Book:

1. Thurman, H.V., & Trujillo, A.P. (2017). Essentials of oceanography (12th ed.). Pearson.
2. Pinet, P.R. (2019). Invitations to oceanography (8th ed.). Jones & Bartlett Learning.
3. Summerhayes, C.P., & Thorpe, S.A. (Eds.). (1996). Oceanography: An illustrated guide. Manson Publishing.
4. Reddy, A.N. (2015). Oceanography (2nd ed.). BS Publications.
5. King, C. (2006). Oceanography: A laboratory manual. McGraw-Hill.
6. National Institute of Oceanography. (2010). Basic oceanographic methods. NIO Publications.

V. RESEARCH COURSES- RC 2: (In lieu of AMJ 2 & AMJ 3)
RESEARCH/ PROJECT DISSERTATION/ RESEARCH INTERNSHIP/ FIELD WORK

Marks: 50 (SIE: 25 Synopsis + 25 Viva on Synopsis: 1Hr) + 100 (ESE Pr: 6Hrs) + 50 (Viva) = 200	**Pass Marks = 80**

(Only for Hons with Research Degree)

Guidelines to Examiners for Semester Internal Examination (SIE):
Evaluation of project dissertation work may be as per the following guidelines:
Project Synopsis = 25 marks
Project Synopsis presentation and viva-voce = 25 marks

Guidelines to Examiners for End Semester Examination (ESE):
Evaluation of project dissertation work may be as per the following guidelines:
Project model (if any) and the Project record notebook = 70 marks
Project presentation and viva-voce = 30 marks

The overall project dissertation may be evaluated under the following heads:

- *Motivation for the choice of topic*
- *Project dissertation design*
- *Methodology and Content depth*
- *Results and Discussion*
- *Future Scope & References*
- *Participation in an Internship programme with a reputed organization*
- *Application of the Research technique in Data collection*
- *Report Presentation*
- *Presentation style*
- *Viva-voce*

Research Project
Research project under a Supervisor of the Department/Institution may be allocated to the eligible and qualifying candidate.

Project Dissertation/ Research Internship/ Field Work
The students of post-graduation must work Thirty-Six (36) days as Interns under Any Organization having an MoU with the Ranchi University, which may include Government Organizations/judiciary/ Health Care Sectors/ Educational Institutions/ NGOs etc.

- The nature and the place of working must be informed in writing, seeking permission from the head of the department or the institution before undertaking the Project dissertation.

Submission of the Project Work
Each student has to submit two copies of the dissertation work duly forwarded by the HOD of the Department concerned. The forwarded copies will be submitted to the Department/Institution for evaluation at least seven days before the seminar.

The Project Report will consist of:

a. Field work/Lab work related to the project.
b. Preparation of the dissertation based on the work undertaken.
c. Presentation of project work in the seminar on the assigned topic & open viva there on.
d. At least one Research paper must be presented at a conference or may be published in a reputed journal.

Topics
Project work related to the Industrial/socially relevant topics may be given.
NB: Students will select topics for the project work in consultation with a teacher of the department.
The seminar will be held in the respective University Department at Ranchi University, Ranchi.

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

ASSOCIATED CORE COURSE- MN A **Either may be opted in Sem-I or Sem-II**

I. ASSOCIATED CORE COURSE- MN A: INTRODUCTORY GEOLOGY

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40**

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

Course Objectives:

1. Develop comprehensive knowledge of Earth as a dynamic planet within the solar system, including its internal structure and surface processes.
2. Examine geological applications in engineering projects, energy resources, and mineral economics relevant to India's development.
3. Introduce rock classification, formation processes, and fossil applications for understanding geological evolution.
4. Foster awareness of natural hazards like earthquakes and volcanoes alongside sustainable resource utilization.

Course Learning Outcomes (CMOs):

Upon successful completion of this course, students will be able to:

1. Describe Earth's position in the solar system, internal layers, physiographic divisions of India, and applications of geology in engineering projects.
2. Classify minerals by properties and distribution, identify rock types with their textures and formation processes.
3. Explain renewable/non-renewable energy sources, India's major energy needs, and basics of weathering, erosion, and metamorphism.
4. Recognize fossil preservation modes and applications in stratigraphic correlation and paleoenvironmental reconstruction.

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

II. ASSOCIATED CORE COURSE- MN A PR:

GEOLOGY MINOR-A PRACTICAL

Marks: Pr (ESE: 6Hrs) = 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 6Hrs 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. Ramakrishnan, M., & Vaidyanadhan, R. (2008). Geology of India. Geological Society of India.
2. Mahadevan, T.M. (2002). Geology of Bihar and Jharkhand. Geological Society of India.
3. Key for Jharkhand minerals distribution and regional physiography/resources.
4. Singh, P. (2012). Engineering geology (9th ed.). S. K. Kataria & Sons.
5. Valdiya, K.S. (2010). The making of India: Geodynamic evolution (2nd ed.). Society of Earth Scientists/Springer.
6. Jain, P. C., & Banerjee, D.M. (2018). Textbook of engineering geology (3rd ed.). Dhanpat Rai Publications.
7. Sharma, R. S. (2017). Basics of paleontology. Geological Society of India.

MINOR COURSE-B

I. MINOR COURSE- MN-B:
ESSENTIALS OF GEOLOGY, ROCKS AND MINERALS

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40**

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

Course Objectives:

1. Provide comprehensive introduction to geology's scope, sub-disciplines, and interdisciplinary connections with planetary and earth sciences.
2. Explain Earth's internal structure, solar system context, geodynamic processes including plate tectonics, earthquakes, and volcanism.
3. Develop understanding of minerals, rocks, and fossils through classification, optical properties, and formation mechanisms.
4. Enable recognition of geological time principles using radioactivity and practical applications in earth resource evaluation.

Course Learning Outcomes (CMOs):

Upon successful completion of this course, students will be able to:

1. Describe Earth's position in solar system, internal layers (core, mantle, crust), plate tectonics fundamentals, and major geohazards distribution.
2. Classify minerals by physical/optical properties using petrological microscope and identify silicate structures.
3. Differentiate rock types (igneous, sedimentary, metamorphic) by texture, structure, formation processes, and Bowen's reaction series.
4. Explain fossil preservation modes, uses in stratigraphy, and apply radioactivity concepts for determining geological ages.

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 and (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. Duff, P. McL. D., Holmes, A., & Bennett, M. (1992). Holmes' principles of physical geology (4th ed.). 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 (2nd ed.). Prentice Hall.
4. Grotzinger, J., & Jordan, T.H. (2010). Understanding Earth (6th ed.). W. H. Freeman and Company.
5. Holmes, A., & Holmes, D.L. (1992). Holmes' principles of physical geology (4th ed.). Chapman & Hall.
6. Klein, C., & Philpotts, A.R. (2013). Earth materials: Introduction to mineralogy and petrology. Cambridge University Press.
7. Plummer, C.C., Carlson, D.H., & Hammersley, L. (2016). Physical geology & the environment (5th ed.). McGraw-Hill Education.
8. Press, F., Siever, R., Grotzinger, J., & Jordan, T.H. (2000). Understanding Earth (3rd ed.). W. H. Freeman.
9. Tarbuck, E. J., Lutgens, F. K., & Tasa, D. (2020). Essentials of geology (14th ed.). Pearson.

MINOR COURSE- MN B PR:
GEOLOGY MINOR-B PRACTICAL

Marks: Pr (ESE: 6Hrs) = 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 6Hrs 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 specimens:
4. Plotting of major Dams on the outline map of India, mention the name of the river and the 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. Bennison, G.M. (1990). An introduction to geological structures and maps (5th ed.). Edward Arnold.
2. Dyar, M.D., Gunter, M.E., & Tasa, D. (2008). Mineralogy and optical mineralogy [Laboratory manual]. Mineralogical Society of America.
3. Kerr, P.F. (1977). Optical mineralogy (4th ed.). McGraw-Hill.
4. Klein, C. (2007). Minerals and rocks: Exercises in crystal, physical, and chemical geosciences. Springer.
5. Lisboa, J.L.D. (2019). Geological structures: A practical introduction [Open textbook]. Kwantlen Polytechnic University.
6. McNamee, M., & Gunter, M.E. (2013). Mineralogy and optical mineralogy lab manual. Mineralogical Society of America.
7. Perkins, D. (2011). Mineralogy (3rd ed.). Pearson.
8. Pollard, D.D., & Fletcher, R.C. (2020). Structural geology: A quantitative introduction. Cambridge University Press.
9. Ragan, D.M. (2009). Structural geology: An introduction to geometrical techniques (4th ed.). Cambridge University Press.
10. Sen, A.K. (1995). Laboratory manual of geology. Modern Book Agency Pvt. Ltd.
11. Singh, R.P. (1995). Structural geology: A practical approach. Ganga Kaveri Publication House.

MINOR COURSE-C

I. MINOR COURSE- MN C:
EARTH RESOURCES

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40

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

Course Objectives:

1. Introduce fundamental concepts of mineral resources, classification of deposits, and strategic minerals critical for national development.
2. Examine renewable and non-renewable energy sources with their environmental implications and distribution patterns.
3. Develop understanding of groundwater resource management, rainwater harvesting, and watershed development techniques.
4. Analyse surface-subsurface water interactions and water balance concepts for sustainable resource planning.

Course Learning Outcomes (CMOs):

Upon successful completion of this course, students will be able to:

1. Define mineral, ore, gangue, tenor, grade and classify mineral deposits by formation processes and economic importance.
2. Differentiate primary/secondary energy sources, identify major energy resources (coal, oil, gas, nuclear, renewables) and their environmental impacts.
3. Explain groundwater management strategies including rainwater harvesting, artificial recharge, and watershed management practices.
4. Describe groundwater level fluctuations, surface-subsurface water interactions, and apply basic water balance study principles.

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 modes 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. Fetter, C.W. (2001). Applied hydrogeology (4th ed.). Prentice Hall.
2. Fowler, J.M. (1984). Energy and the environment. McGraw-Hill.
3. Ghosh, T.K., & Prelas, M.A. (2009). Energy resources and systems: Fundamentals and non-renewable resources (Vol. 1). Springer.
4. Hiscock, K.M. (2009). Hydrogeology: Principles and practice (2nd ed.). Wiley-Blackwell.
5. Keshavarz, A., & Karimi, M. (2022). Earth's energy resources: Fossil fuels, renewables, and nuclear. Springer.
6. Kesler, S.E., & Simon, A.C. (2015). Earth's mineral resources. Cambridge University Press.
7. Nakicenovic, N., Grübler, A., & McDonald, A. (Eds.). (1998). Global energy perspectives. Cambridge University Press.
8. Robbins, J.C. (2019). Mineral resources economics: Volume 1: An introduction to mineral resource economics. Springer.
9. Sikarwar, V.S., & Cvetković, V. (Eds.). (2021). Earth resources and sustainable development. Springer.
10. Sørensen, B. (2007). Renewable energy conversion, transmission, and storage. Springer.
11. Speight, J.G. (2016). Handbook of offshore oil and gas operations. Gulf Professional Publishing.
12. Todd, D.K., & Mays, L.W. (2005). Groundwater hydrology (3rd ed.). John Wiley & Sons.
13. Wagner, H.J., & Mathur, J. (2009). Introduction to wind energy systems: Basics, technology and operation. Springer.

II. MINOR COURSE- MN C PR:
GEOLOGY MINOR-C PRACTICAL

Marks: Pr (ESE: 6Hrs) = 25	**Pass Marks: Pr (ESE) = 10**

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

Instructions to Question Setter for
End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs 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. Biswas, A.K. (1987). Mineral processing to elemental science in the medieval world: India and Europe. Asiatic Society of India.
2. Ghosh, S.C. (2002). The coal fields of Jharkhand: Coal resources of Jharkhand. Geological Survey of India.
3. Iyengar, R.N., & Sharma, S. (2007). Earthquake hazard mapping in India. National Information Centre of Earthquake Engineering.
4. Krishnaswamy, S. (1972). India's minerals and energy resources. Macmillan.
5. Roonwal, G.S. (2010). Mineral resources of India. Oxford & IBH Publishing.
6. Sinha, R.K. (2015). Coal geology of India. Scientific Publishers.
7. Srivastava, S.C. (1995). Ore deposits of India. Allied Publishers.
8. Viswanathiah, M.N., & Sen, A.K. (1993). Practical geology (3rd ed.). Tata McGraw-Hill.

MINOR COURSE-D

I. MINOR COURSE- MN D:
FOSSILS AND THEIR APPLICATIONS

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40

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

Course Objectives:

1. Introduce fundamental concepts of fossilization processes, preservation modes, and species taxonomy in paleontological studies.
2. Examine morphology, geological history, and stratigraphic significance of major invertebrate fossil groups.
3. Develop understanding of paleontological applications in reconstructing paleoecology, paleobiogeography, and paleoclimate.
4. Highlight societal and industrial importance of fossils in hydrocarbon exploration, coal correlation, and environmental monitoring.

Course Learning Outcomes (CMOs):

Upon successful completion of this course, students will be able to:

1. Define fossils, explain fossilization processes, identify modes of preservation, and describe their stratigraphic uses.
2. Apply species concepts for fossil description, naming, and classification of major groups like Brachiopoda, Gastropoda, and Lamellibranchia.
3. Recognize important Indian fossiliferous horizons and interpret fossil evidence for paleoenvironmental reconstruction.
4. Evaluate applications of benthic/micropaleontology in hydrocarbon reservoir identification and spores/pollen in coal seam correlation.

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. Benton, M.J. & Harper, D.A.T. (2009). Introduction to Paleobiology and the Fossil Record, Wiley-Blackwell.
2. Benton, M.J., 2005. Vertebrate Palaeontology. 3rd ed. Blackwell Publishing, Oxford.
3. Carrasco, M.A. (2016). Paleontology: A Philosophical Introduction, Cambridge University Press (for conceptual and methodological context).
4. Clarkson, E.N.K., 1998. Invertebrate Palaeontology and Evolution. 3rd ed. George Allen & Unwin, London.
5. Colbert, E.H., Morales, M. and Minkoff, E., 1991. Evolution of the Vertebrates: A History of the Backboned Animals Through Time. 4th ed. John Wiley & Sons, New York.
6. Long, J.A. (2011). The Rise of Fishes: 500 Million Years of Evolution (2nd ed.), Johns Hopkins University Press.
7. Miall, A.D. (2010). The Geology of Stratigraphic Sequences (2nd ed.), Springer.
8. Prothero, D.R. (2013). Bringing Fossils to Life: An Introduction to Paleobiology (3rd ed.), Columbia University Press.
9. Prothero, D.R., 1998. Bringing Fossils to Life: An Introduction to Paleobiology. McGraw-Hill, New York.
10. Reading, H.G. (Ed.) (1996). Sedimentary Environments: Processes, Facies and Stratigraphy (3rd ed.), Blackwell Science.
11. Sadler, P.M. (2004). Stratigraphy: A Concept-Based Approach from the Outside In. McGraw-Hill.
12. Salvador, A. (Ed.) (1994). International Stratigraphic Guide (2nd ed.), Wiley-Interscience.
13. Schoch, R.M., 1989. Stratigraphy: Principles and Methods. Van Nostrand Reinhold, New York.

II. MINOR COURSE- MN D PR:
GEOLOGY MINOR-D PRACTICAL

Marks: Pr (ESE: 6Hrs) = 25	**Pass Marks: Pr (ESE) = 10**

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

Instructions to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs 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. Schoch, R.M., 1989. Stratigraphy: Principles and Methods. Van Nostrand Reinhold, New York.
2. Clarkson, E.N.K., 1998. Invertebrate Palaeontology and Evolution. 3rd ed. George Allen & Unwin, London.
3. Prothero, D.R., 1998. Bringing Fossils to Life: An Introduction to Paleobiology. McGraw-Hill, New York.
4. Benton, M.J., 2005. Vertebrate Palaeontology. 3rd ed. Blackwell Publishing, Oxford.
5. Bastia, R., 2005 (or similar Indian-authored works) / or regional geological survey volumes: Fossiliferous Formations of India (e.g., GSI publications, state-wise stratigraphic reports) or
6. Biswas, S.K. (1992). Geology of Kutch Basin, Western India (or other basin-specific volumes).
7. Genge, M.J., 2020. Geological Field Sketches and Illustrations: A Practical Guide. Oxford University Press.

MINOR COURSE-E

I. MINOR COURSE- MN E:
STRUCTURAL GEOLOGY

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40

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

Course Objectives:

After completion of the course, the learner shall be able to understand:

1. To introduce basic concepts of structural geology and rock deformation
2. To develop understanding of geological structures like folds, faults, joints
3. To train students in interpretation of geological maps and structures
4. To provide basic practical skills in structural analysis

Course Learning Outcomes:

On successful completion of this course the student should know:

1. After completion of the course, students will be able to:
2. Understand stress, strain and deformation mechanisms in rocks
3. Identify and describe major geological structures in field and maps
4. Measure and interpret strike and dip of planar features
5. Analyze folds, faults and joints in geological context
6. Interpret simple geological maps and structural data
7. Apply basic stereographic projection techniques.

Course Content:

Unit 1: Introduction to Structural Geology, Definition, scope and importance of Structural Geology, Stress and strain, Types of deformation: elastic, plastic, brittle, Factors controlling rock deformation.

Unit 2: Planar Structures, Attitude of beds: strike and dip (measurement techniques), Primary structures: bedding, lamination, Secondary planar structures:, Cleavage (types: slaty, schistosity, fracture cleavage), Foliation, Unconformity.

Unit 3: Linear Structures and Joints, Lineation: types (mineral, stretching, intersection lineation), Pitch and plunge, Joints: classification and significance, Shear zones: concept and identification

Unit 4: Folds, Definition and elements of folds (hinge, limb, axial plane, plunge), Types of folds, causes of fold.

Unit 5: Faults and Geological Structures, Faults: definition and terminology, Types of faults, Causes of fault..

Reference Books:

1. Billings, M.P. – Structural Geology
2. Hobbs, Means & Williams – An Outline of Structural Geology
3. Ramsay, J.G. – Folding and Fracturing of Rocks
4. Park, R.G. – Foundations of Structural Geology
5. Twiss & Moores – Structural Geology
6. Davis, G.H. – Structural Geology of Rocks and Regions

II. MINOR COURSE- MN E PR:
GEOLOGY MINOR-E PRACTICAL

Marks: Pr (ESE: 6Hrs) = 25	**Pass Marks: Pr (ESE) = 10**

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

Instructions to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs 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. Measurement of Planar Structures, Use of compass clinometers, Measurement of strike and dip of beds, Recording of field data in tabular form
2. Contour Map Reading and Profiling, Identification of contour patterns, Drawing of topographic profiles from contour maps
3. Interpretation of Geological Maps, Geological maps with horizontal and dipping beds, Determination of strike and dip from maps, Identification of folds and faults
4. Introduction to Stereographic Projection (Basic). Basic concept of stereographic projection, Simple understanding of plotting planes.

Reference Books

1. Gokhale – Practical Geology
2. Billings – Structural Geology
3. Compton – Geological Field Techniques
4. Ragan – Structural Geology: An Introduction to Geometrical Techniques.

MINOR COURSE-F

I. MINOR COURSE- MN F: HYDROGEOLOGY

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40

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

Course Objectives:

After completion of the course, the learner shall be able to understand:

1. To introduce fundamentals of groundwater and hydrological processes
2. To understand occurrence and movement of groundwater
3. To develop knowledge about aquifers and well systems
4. To create awareness about groundwater management and conservation

Course Learning Outcomes:

On successful completion of this course the student should know:

1. After completion of the course, students will be able to:
2. Explain hydrological cycle and origin of groundwater
3. Identify different types of aquifers and their properties
4. Understand basic principles of groundwater flow (Darcy's law concept)
5. Describe different types of wells and groundwater systems
6. Assess basic groundwater quality parameters
7. Understand groundwater conservation and management practices

Course Content:

Unit 1: Introduction to Hydrogeology, Definition, scope and importance of Hydrogeology, Hydrologic cycle and its components, Distribution of water on Earth, Origin of groundwater, Types of water: meteoric, connate, juvenile

Unit 2: Properties of Aquifers and Groundwater, Porosity and permeability, Specific yield and specific retention, Types of aquifers: Unconfined, confined, semi-confined (leaky), perched aquifer, Aquiclude, aquitard, aquifuge

Unit 3: Groundwater Movement and Wells, Groundwater flow: hydraulic gradient, Flow through porous media

Types of wells: dug wells, tube wells, artesian wells, Cone of depression

Unit 4: Groundwater Exploration and Quality, Methods of groundwater exploration: Geological methods, Geophysical methods (electrical resistivity – basic idea), Groundwater quality: Physical and chemical parameters, Sources of groundwater pollution

Unit 5: Groundwater Management and Environmental Aspects, Groundwater recharge and discharge, Rainwater harvesting, Over-exploitation of groundwater, Groundwater conservation and management, Role of groundwater in environmental geology

Reference Books:

1. K.R. Karanth – Groundwater Assessment Development and Management
2. H.M. Raghunath – Groundwater
3. Fetter – Applied Hydrogeology

II. MINOR COURSE- MN F PR:
GEOLOGY MINOR-F PRACTICAL

Marks: Pr (ESE: 6Hrs) = 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 6Hrs duration. Evaluation of the 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 Hydrological Cycle, Simple diagram of hydrological cycle, Identification of main components: rainfall, evaporation, infiltration
2. Identification of Aquifers (Using Diagrams/Models), Types of aquifers: Unconfined, Confined, Perched
3. Basic understanding of groundwater occurrence
4. Basic Idea of Darcy's Law, Simple explanation of groundwater flow, Demonstration
5. Water Level Measurement (Model/Field Based), Concept of water table, Measuring water level in wells
6. Types of Wells, Dug well, Tube well, Artesian well
7. Groundwater Flow Direction (Simple Exercise), Drawing simple water table map (given data), Understanding direction of flow (high to low level)
8. Rainwater Harvesting (Model Study), Simple rooftop rainwater harvesting system, Importance in water conservation.

Reference Books:

1. H.M. Raghunath – Groundwater
2. K.R. Karanth – Groundwater Assessment Development and Management.

MINOR COURSE-G

I. MINOR COURSE- MN G:
ENGINEERING AND ENVIRONMENTAL GEOLOGY

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40**

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

Course Objectives:

After completion of the course, the learner shall be able to understand:

1. To introduce the application of geology in engineering works
2. To develop an understanding of rocks and soils in construction
3. To create awareness about environmental issues and hazards
4. To promote sustainable use of geological resources

Course Learning Outcomes:

On successful completion of this course the student should know:

1. After completion of the course, students will be able to:
2. Identify common rocks and soils and their engineering properties
3. Understand geological factors affecting construction projects
4. Recognize natural hazards like landslides, earthquakes and floods
5. Explain environmental issues related to geology
6. Understand basic waste management and pollution control methods
7. Apply geological knowledge in environmental conservation

Course Content:

Unit 1: Introduction to Engineering & Environmental Geology, Definition, scope and importance of Engineering Geology, Role of geology in civil engineering projects, Introduction to Environmental Geology, Human–environment interaction, Concept of sustainable development

Unit 2: Engineering Properties of Rocks and Soils, Physical and mechanical properties of rocks, Weathering and its engineering significance, Soil formation and classification, Engineering properties of soils (permeability, porosity, shear strength), Rock mass classification (basic concept)

Unit 3: Geological Considerations in Civil Engineering Projects, Dams and reservoirs: site selection and geological problems, Tunnels: geological factors and hazards, Roads and highways: slope stability and landslides, Foundations: types and geological considerations

Unit 4: Environmental Issues and Hazards, Natural hazards: earthquakes, landslides, floods, Environmental degradation due to mining and urbanization, Soil and water pollution, Waste disposal and management, Environmental impact assessment (EIA) – basic concept

Unit 5: Groundwater and Environmental Management, Role of groundwater in environmental geology, Groundwater pollution and control, Watershed management, Conservation of natural resources, Environmental laws and policies (basic awareness)

Reference Books:

1. Krynine & Judd – Principles of Engineering Geology and Geotechnics
2. Parbin Singh – Engineering and General Geology
3. K.S. Valdiya – Environmental Geology
4. Keller – Environmental Geology

II. MINOR COURSE- MN G PR:
GEOLOGY MINOR-G PRACTICAL

Marks: Pr (ESE: 6Hrs) = 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 6Hrs 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. Identification of Common Rocks (Engineering Use), Megascopic identification of rocks: Granite, Basalt, Sandstone, Limestone, Basic engineering uses of each rock
2. Study of Soil Types, Identification of soil types: sand, silt, clay, Simple field tests (touch/feel method), Basic idea of soil properties
3. Simple Slope Study, Identification of stable and unstable slopes (diagram/photo), Basic idea of landslide-prone conditions
4. Study of Natural Hazards, Identification through pictures/diagrams: Landslides, Earthquakes, Floods, Basic mitigation awareness
5. Waste Management, Types of waste: solid and liquid, Methods of disposal (landfill, recycling – basic idea)
6. Field Visit / Report, Visit to nearby construction site/quarry / polluted area, Observation and preparation of a short report.

Reference Books:

1. Parbin Singh – Engineering and General Geology
2. K.S. Valdiya – Environmental Geology
