



FYUGP

GEOLOGY HONOURS/ RESEARCH SYLLABUS

UP TO SEMESTER-IV

FOR UNDER GRADUATE COURSES UNDER
BINOD BIHARI MAHTO KOYALANCHAL UNIVERSITY, DHANBAD



Implemented from
Academic Session 2023-2027





UNIVERSITY DEPARTMENT OF GEOLOGY
BINOD BIHARI MAHTO KOYALANCHAL UNIVERSITY,
DHANBAD- 828130 (JHARKHAND)

Memo No: BBM KU/R/1264/2023, dated on 21.07.23

As per Guidelines of the Binod Bihari Mahto Koyalanchal University, Dhanbad, Syllabus for undergraduate courses of Geology honours/research under NEP-2020 was prepared by Members of Board of Studies of FYUGP. List of members are following below

Name of Members	Signature
1. Dr. J. N. Singh Dean, Faculty of Science, Head, Geology Dept. BBMK Univ. Dhanbad	-Chairman
2. Dr. Atul Kumar Sinha, University Dept. of Geology, BBMK Univ. Dhanbad	- Member
3. Dr. Sagar Kumar Swain, HoD, Dept. of Geology, PKRMC, BBM KU Univ. Dhanbad	-Member
4. Dr. Krishna Gopal, University Dept. of Geology, BBMK Univ. Dhanbad	-Member
5. Prof. Prem Prakash Singh Former Head, Department of Geology, Utkal University, Bhubaneswar	-External expert

COURSE STRUCTURE FOR FYUGP 'HONOURS/ RESEARCH'

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

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

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

SEMESTER WISE COURSES OF STUDY FOR FOUR YEAR UNDERGRADUATE PROGRAMME 2023 onwards

Table 2: Semester wise Course Code and Credit Points:

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		
	Code	Papers	Credits
I	AEC-1	Language and Communication Skills (Modern Indian language including TRL)	2
	VAC-1	Value Added Course-1	4
	SEC-1	Skill Enhancement Course-1	3
	MDC-1	Multi-disciplinary Course-1	3
	MN-1A	Minor from Discipline-1	4
	MJ-1	Major paper 1 (Disciplinary/Interdisciplinary Major)	4
II	AEC-2	Language and Communication Skills (English)	2
	SEC-2	Mathematical & Computation Thinking Analysis	3
	MDC-2	Multi-disciplinary Course-2	3
	MN-2A	Minor from Vocational Studies/Discipline-2	4
	MJ-2	Major paper 2 (Disciplinary/Interdisciplinary Major)	4
	MJ-3	Major paper 3 (Disciplinary/Interdisciplinary Major)	4
III	AEC-3	Language and Communication Skills (Modern Indian language including TRL)	2
	SEC-3	Skill Enhancement Course-3	3
	MDC-3	Multi-disciplinary Course-3	3
	MN-1B	Minor from Discipline-1	4
	MJ-4	Major paper 4 (Disciplinary/Interdisciplinary Major)	4
	MJ-5	Major paper 5 (Disciplinary/Interdisciplinary Major)	4
IV	AEC-3	Language and Communication Skills (MIL-2/English-2)	4
	VAC-2	Value Added Course-2	2
	MN-2B	Minor from Vocational Studies/Discipline-2	4
	MJ-6	Major paper 6 (Disciplinary/Interdisciplinary Major)	4
	MJ-7	Major paper 7 (Disciplinary/Interdisciplinary Major)	4
	MJ-8	Major paper 8 (Disciplinary/Interdisciplinary Major)	4
V	MN-1C	Minor from Discipline-1	4
	MJ-9	Major paper 9 (Disciplinary/Interdisciplinary Major)	4
	MJ-10	Major paper 10 (Disciplinary/Interdisciplinary Major)	4
	MJ-11	Minor Paper 3 (Disciplinary/Interdisciplinary Minor)	4
	IAP	Internship/Apprenticeship/ Field work / Dissertation/ Project	4
VI	MN-2C	Minor from Vocational Studies/Discipline-2	4
	MJ-12	Major paper 12 (Disciplinary/Interdisciplinary Major)	4
	MJ-13	Major paper 13 (Disciplinary/Interdisciplinary Major)	4
	MJ-14	Minor Paper 14 (Disciplinary/Interdisciplinary Minor)	4
	MJ-15	Minor Paper 15 (Disciplinary/Interdisciplinary Minor)	4
VII	MN-1D	Minor from Discipline-1	4
	MJ-16	Major paper 16 (Disciplinary/Interdisciplinary Major)	4
	MJ-17	Major paper 17 (Disciplinary/Interdisciplinary Major)	4
	MJ-18	Minor Paper 18 (Disciplinary/Interdisciplinary Minor)	4
	MJ-19	Minor Paper 19 (Disciplinary/Interdisciplinary Minor)	4
VIII	MJ-20	Major paper 20 (Disciplinary/Interdisciplinary Major)	4
	RC/	Research Internship/ Field work/ Dissertation	12/
	AMJ-1	Advanced Major paper-1 (Disciplinary/Interdisciplinary Major)	4
	AMJ-2	Advanced Minor Paper 18 (Disciplinary/Interdisciplinary Minor)	4
	AMJ-3	Advanced Minor Paper 19 (Disciplinary/Interdisciplinary Minor)	4
Total Credits			160

Abbreviations:

AEC Ability Enhancement Courses

SEC Skill Enhancement Courses

IAP	Internship/Apprenticeship/ Project
MDC	Multidisciplinary Courses
MJ	Major Disciplinary/Interdisciplinary Courses
DMJ	Double Major Disciplinary/Interdisciplinary Courses
AMJ	Advance Major Disciplinary/Interdisciplinary Courses
MN	Minor Disciplinary/Interdisciplinary Courses
RC	Research Courses

AEC (Ability enhancements courses)- 2 Credits

- Full marks – 50, Pass Marks – 20
- In AEC the students of all faculties will have to select either Hindi or English in Semester -1 and those students who have opted Hindi will have to select English as AEC in Semester -2 and vice versa. For 3rd and 4th semester student can opt Sanskrit, Urdu, Bengali, English, Hindi or TRL.
- In 4th semester there will be AEC-3 will include Language and Communication Skill in Hindi and English.
- No internal examination will be conducted.

VAC (Value added Courses)- 2 Credits

- Full marks – 50, Pass Marks – 20
- For 1st semester – “Understanding India”
- For 4th Semester – “Environmental Studies”
- No internal examination will be conducted.

SEC (Skill Enhancement Courses) – 3 Credits

- Full Marks – 75, Pass Marks – 30
- Digital Education or Mathematical & Computational Thinking Analysis is selected as SEC. Student will have to select or opt either of the two subjects for semester – I, II and III in no case both subjects will be allowed to opt.
- No internal examination will be conducted.

MDC (Multidisciplinary Courses) – 3 credits

- Full Marks – 75, Pass Marks – 30
- A student will study three different subjects in the multidisciplinary courses during first three semesters.
- No internal examination will be conducted.

SEMESTER WISE COURSES OF STUDY FOR FOUR YEAR UNDERGRADUATE PROGRAMME 2023 onwards

Table 3: Semester wise Course Code and Credit Points and Marks distribution of Major Papers:

S.N.	Semester	Paper	Credit	Full Marks-100			Pass Marks		
				Internal Theory (Mid Sem.)	End sem. Theory	End sem. Practical	Internal Theory (Mid Sem.)	End Sem. Theory	End sem. Practical
1.	I	MJ-1: Theory	4	25	75	-	10	30	-
2.	II	MJ-2: Theory	4	25	75	-	10	30	-
		MJ-3: Practical- I	4	-	-	100	-	-	40
3.	III	MJ-4: Theory	4	25	75	-	10	30	-
		MJ-5: Practical- II	4	-	-	100	-	-	40
4.	IV	MJ-6: Theory	4	25	75	-	10	30	-
		MJ-7: Theory	4	25	75	-	10	30	-
		MJ-8: Practical-III	4	-	-	100	-	-	40
5.	V	MJ-9: Theory	4	25	75	-	10	30	-
		MJ-10: Theory	4	25	75	-	10	30	-
		MJ-11: Practical-IV	4	-	-	100	-	-	40
6.	VI	MJ-12: Theory	4	25	75	-	10	30	-
		MJ-13: Theory	4	25	75	-	10	30	-
		MJ-14: Theory	4	25	75	-	10	30	-
		MJ-15: Practical-V	4	-	-	100	-	-	40
7.	VII	AMJ-01: Theory	4	25	75	-	10	30	-
		AMJ-02: Theory	4	25	75	-	10	30	-
		AMJ-03: Theory	4	25	75	-	10	30	-
		AMJ-04: Practical-VI	4	-	-	100	-	-	40
8.	VIII	AMJ-05: Theory	4	25	75	-	10	30	-

- Total theory papers will be 14 and practical papers will be 6.
- No internal or mid semester examination will be conducted for practical papers.

Table 4: Semester wise Course Code and Credit Points and Marks distribution of Minor Papers:

S.N.	Semester	Paper	Credit	Full Marks		Pass Marks	
				Theory (Internal+ End Sem)	Practical End Sem.	Theory (Internal+ End Sem)	Practical
1.	I	MN-1A	3+1	15+60	25	30	10
2.	III	MN-1B	3+1	15+60	25	30	10
3.	V	MN-1C	3+1	15+60	25	30	10
4.	VII	MN-1D	3+1	15+60	25	30	10

- No internal or mid semester examination will be conducted for practical papers.

SEMESTER WISE COURSES IN GEOLOGY FOR FYUGP

2023 onwards**Table 5: Semester wise Papers and Examination Structure for Geology Major:**

Semester	Geology Major		Examination Structure				Pass Marks		
	Code	Papers	Credits	Internal (Mid Semester) Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical (F.M.)	Internal Theory (Mid Sem.)	End Sem. Theory	End sem. Practical
I	MJ-1: Theory	Earth System Science	4	25	75		10	30	-
II	MJ-2: Theory	Structural Geology	4	25	75		10	30	-
	MJ-3: Practical	Practical				100	-	-	40
III	MJ-4: Theory	Igneous Petrology	4	25	75		10	30	-
	MJ-5: Practical	Practical				100	-	-	40
IV	MJ-6: Theory	Sedimentary Petrology	4	25	75		10	30	-
	MJ-7: Theory	Metamorphic Petrology	4	25	75		10	30	-
	MJ-8: Practical	Practical				100	-	-	40

Table 6: Semester wise Papers and Examination Structure for Geology Minor:

Semester	Code	Minor Papers	Credits	Full Marks		Pass Marks	
				Theory (Internal+ End Sem)	Practical End Sem.	Theory (Internal+ End Sem)	Practical
I	MN-1A	Introductory Geology	3+1	15+60	25	30	10
III	MN-1B	Essentials of Geology, Rocks & Minerals	3+1	15+60	25	30	10

**NEP UG Syllabus
Semester I****Major – 1 (MJ - 1) EARTH SYSTEM SCIENCE****Credit – 4****FM= 100****Lectures – 60 Hours****T= 100 {75Ext. +25 Int.}****Instructions:**

- There will be two groups 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 of **short answer type of 5 marks each**.
- **Group B** will contain **descriptive type six questions of 15 marks each**, out of which **any four are to answer**.

Course Objective:

This course aims in helping the students:

- To know the basic of geology, its scope and its various branches
- To introduce fundamental aspects of Earth and Planetary system and its related changes with time.
- This course will emphasize the knowledge on the solar system and planets, interior of Earth, Plate Tectonics
- Knowledge on Hydrosphere and Atmosphere, Soil, Understanding the past from stratigraphic records
- Learn the basics of crystallography and its application to optical mineralogy;
- Understand the fundamental concepts of crystal structure, morphology and its application to mineral sciences. Optical mineralogy part will help the student to understand microscopic techniques applicable to mineralogical and petrographic studies.

Learning Outcomes:

After successfully completing this course, the students will be able to understand:

- The aim of this course is to study the major mineral groups, their occurrences, physical, chemical and crystallographic properties and their possible uses in industry.
- The course aims also to study the external symmetry of the crystals through external elements of symmetry, crystal classes and systems, and the relations of symmetry to the internal structure using the chemical and physical properties of the minerals.
- Focus is given on the physical and chemical properties of minerals, from macroscopic to microscopic.
- The course will investigate how geologic materials and processes influence mineral occurrence, stability, and composition.
- The course is divided into different modules as given in the course content and covers the structure of minerals, characters of minerals and mineral chemistry.

Skills to be Learned

- Problem-solving skills and creativity thinking
- The ability to recognize and understand complex patterns systems

COURSE CONTENT:

Unit	Topic	Total no. of Lectures
Unit 1: Earth as a planet, Interior of Earth, Plate Tectonics		
1.1	Earth as a planet: 1.1.1: General characteristics and origin of the Universe, Solar System and its planets. The terrestrial and jovian planets. Meteorites and Asteroids,	04
	1.1.2: Earth in the solar system - origin, size, shape, mass, density, rotational and revolution parameters and its age.	04
1.2	Interior of Earth 1.2.1: Internal Structure of the earth & Composition	02
	1.2.2: Primary & Secondary discontinuity with depth	02
	1.2.3: Earth's magnetic field: Convection in Earth's core and production of its magnetic field	02
1.3	Plate Tectonics 1.3.1: Concept of plate tectonics, sea-floor spreading, Isostasy and continental drift	04
	1.3.2: Geodynamic elements of Earth- Mid Oceanic Ridges, trenches, transform faults and island arcs Origin of oceans, continents, mountains and rift valleys	04
	1.3.3: Earthquake, earthquake belts, distribution, Scale Volcanoes- types, products and their distribution	04
Unit 2: Hydrosphere and Atmosphere, Soil, Understanding the past from stratigraphic records		Total no. of Lectures
2.1	Hydrosphere and Atmosphere 2.1.1: Introduction to hydrosphere and atmosphere; Oceanic current system and effect of Coriolis force; Wave erosion and beach processes; Atmospheric circulation; Earth's heat budget.	04
	2.1.2: Soils- processes of formation, soil profile and soil types.	02
2.2	2.2.1: Understanding the past from stratigraphic records: Stratigraphy: introduction and scope; Standard stratigraphic time scale, Introduction to geochronological methods and their application in geological studies; Laws of superposition and faunal succession; Concepts of uniformitarianism.	04

Unit 3: Crystallography, Crystal symmetry and projections		Total no. of Lectures
3.1	Crystallography: 3.1.1: Elementary ideas about crystal morphology in relation to internal structures Crystal parameters and indices Crystal symmetry and classification of crystals into six systems and 32 point groups	06
3.2	Crystal symmetry and projections 3.2.1: Elements of crystal chemistry and aspects of crystal structures Stereographic projections of symmetry elements and forms	04
Unit 4: Rock forming minerals		Total no. of Lectures
4.1	Rock forming minerals 4.1.1: Minerals - definition and classification, physical and chemical properties Composition of common rock-forming minerals, Silicate and non-silicate structures; CCP and HCP structures	06
Unit 5: Properties of light and optical microscopy		Total no. of Lectures
	Properties of light and optical microscopy Nature of light and principles of optical mineralogy, Isotropic & Anisotropic, Birefringence, Interference color, Extinction, Uniaxial & Biaxial Indicatrix, Introduction to the petrological microscope and identification of common rock-forming minerals	08

Books Recommended

- Duff, P. M. D., & Duff, D. (Eds.). (1993). *Holmes' principles of physical geology*. Taylor & Francis.
- Emiliani, C. (1992). *Planet earth: cosmology, geology, and the evolution of life and environment*. Cambridge University Press.
- Gross, M. G. (1977). *Oceanography: A view of the earth*.
- 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.
- Kerr, P. F. (1959). *Optical Mineralogy*. McGraw-Hill.
- Verma, P. K. (2010). *Optical Mineralogy (Four Colour)*. Ane Books Pvt Ltd.
- Deer, W. A., Howie, R. A., & Zussman, J. (1992). *An introduction to the rock-forming minerals (Vol. 696)*. London: Longman.

Semester II

Major – 2 (MJ - 2) STRUCTURAL GEOLOGY**Credit – 4****FM= 100****Lectures – 60 Hours****T= 100 {75Ext. +25 Int.}****Instructions:**

- There will be two groups 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 of **short answer type of 5 marks each**.
- **Group B** will contain **descriptive type six questions of 15 marks each**, out of which **any four are to answer**.

Course Objective:

The primary objective of the course is:

- To provide student the fundamental ideas about different structures in structural geology.
- To provide fundamentals of plate tectonics

Learning outcomes

After successfully completing this course, the students will be able to understand:

- This course helps the students to understand how to use structures and appreciate the dynamic nature of the Earth's lithosphere.
- The students will learn the skills of identifying different structure and will be acquainted with field measurements required for geological mapping, learn how to read geologic maps and solve simple map problems and preparations of cross sections.

Skills to be Learned

- Know basic terminologies and concepts in structural geology
- Get familiar with clinometers and measure dip and strike;
- Significance of folds and faults
- Evaluate the geological significance of joints and unconformity;
- Recognize the importance of geological fieldwork;
- Safety measures and field equipment's needed for fieldwork; and
- Discuss about planning and collection of field data and its documentation.

COURSE CONTENT:

Unit	Topic	Total no. of Lectures
Unit 1: Structure and Topography		
1.1	Effects of topography on structural features, Topographic and structural maps; Importance representative factors of the map, compass-Clinometer & Brunton, V's Rule & it significance	02

Unit 2: Stress and strain in rocks		
2.1	Concept of rock deformation: Stress & their type, Strain & their type in rocks, Strain & Stress ellipses of different types and their geological significance. Ductile and brittle deformation, Young's modulus of Elasticity, Concept of dip and strike; pitch and plunge, Outcrop patterns of different structures.	04
Unit 3: Folds		
3.1	Fold morphology; Geometric and genetic classification of folds & recognition of fold in the Field. Introduction to the mechanism of folding: Buckling, Bending, Flexural slip and flow folding, shear zones and their types, Ramsay & Fleuty classification of Fold	10
Unit 4: Foliation and lineation		
4.1	Description, origin & types of foliations and relationship with the major structures and its tectonic significance, Description, origin & types of lineation and relationship with the major structures and its tectonic significance.	06
Unit 5: Fractures, faults and Joints		
5.1	Geometric and genetic classification of faults, Effects of faulting on the outcrops Geologic/geomorphic criteria for recognition of faults and fault plane solutions, Joints types & significance, Unconformities: their types & significance	04

Books Recommended

- *Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley Billings, M. P. (1987) Structural Geology, 4th edition, Prentice-Hall.*
- *Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.*
- *Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.*
- *Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical)*
- *Lahee F. H. (1962) Field Geology. McGraw Hill*

**Practical
Semester II**

Major – 3 (MJ - 3) P (Practical) EARTH SYSTEM SCIENCE & STRUCTURAL GEOLOGY

**Credit – 4
FM= 100 marks**

Lectures – 60 x 2= 120 Hours

Practical Marks	Distribution
1. Experiments from 1-8	10
2. Experiments from 9-10	10
3. Experiments from 11	10
4. Experiments from 12-16	10
5. Experiments from 17-21	10
6. Field Visit Report	10
7. Practical record	20
8. Viva Voce	20
	Total=100

Suggested Practical:

EARTH SYSTEM SCIENCE

1. Study of major geomorphic features and their relationships with outcrops through physiographic models.
2. Detailed study of topographic sheets and preparation of physiographic description of an area
3. Study of soil profile of any specific area
4. Study of distribution of major lithostratigraphic units on the map of India
5. Study of distribution of major dams on map of India and their impact on river systems
6. Study of major ocean currents of the World
7. Study of seismic profile of a specific area and its interpretation
8. Observation and documentation on symmetry of crystals
9. Study of physical properties of minerals in hand specimen: Silicates: Olivine, Garnet, Andalusite, Sillimanite, Kyanite, Staurolite, Beryl, Tourmaline, Augite, Actinolite, Tremolite, Hornblende, Serpentine, Talc, Muscovite, Biotite, Phlogopite, Quartz, Orthoclase, Plagioclase, Microcline, Nepheline, Sodalite, Zeolite, Quartz varieties: Chert, Flint, Chalcedony, Agate, Jasper, Amethyst, Rose quartz, Smoky quartz, Rock crystal.
10. Native Metals/non-metals, Sulfides, Oxides- Copper, Sulfur, Graphite, Pyrite, Corundum, Magnetite Hydroxides, Halides, Carbonates, Sulfates, Phosphates: Psilomelane, Fluorite, Calcite, Malachite, Gypsum, Apatite.
11. Study of some key silicate minerals under optical microscope and their characteristic properties.

STRUCTURAL GEOLOGY

12. Basic idea of topographic contours, Topographic sheets of various scales.
13. Introduction to Geological maps: Lithological and Structural maps

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14. Structural contouring and 3-point problems of dip and strike
15. Drawing profile sections and interpretation of geological maps of different complexities, Exercises of stereographic projections of mesoscopic structural data (planar, linear, folded etc.)
16. Completion of outcrop of maps from partial data.
17. Outcrop pattern of horizontal and dipping beds, fold, fault, unconformity, dyke and sill.
18. Graphical solutions of simple structural problems: dip-strike, true dip-apparent dip.
19. Three-point problems and determination of dip and strike from borehole data.
20. Determination of vertical and true thickness of inclined beds.
21. Drawing of vertical geological sections to illustrate different geological structures.
22. Geological Mapping of two weeks duration in a geologically complex area and Field Work Report based on it

Semester III**Major – 4 (MJ - 4) IGNEOUS PETROLOGY****Credit – 4****FM= 100****Lectures – 60 Hours****T= 100 {75Ext. +25 Int.}****Instructions:**

- There will be two groups 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 of **short answer type** of **5 marks each**.
- **Group B** will contain **descriptive type six questions** of **15 marks** each, out of which **any four** are to answer.

Course Objective:

The primary objective of the course is:

- To provide student the fundamental ideas about igneous rocks.
- To help the student to learn in detail the different igneous rocks, the petrogenetic processes and tectonic environments for their emplacement.

Learning outcomes

After successfully completing this course, the students will be able to:

- understanding of the processes involved in the formation of igneous rocks, their textures, structures, classifications.
- to identify, describe and classify rocks using hand specimens and in thin sections.
- Understand the petrogenesis of igneous rocks

Skills to be Learned

- Know basic terminologies and concepts in igneous petrology
- Significance of magma & igneous rocks
- Understand the diversity of igneous rocks and the variety of tectonic environments for their emplacement.

COURSE CONTENT:

Unit	Topic	Total no. of Lectures
Unit 1: Forms	Magma - nature and composition; forms, Mode of occurrence of igneous rocks, Textures and structures of igneous rocks, Nature and type of partial melting in the mantle. Magmatic Differentiation & its different stages, Assimilation and factors affecting assimilation.	12

<p>Unit 2: Phase diagrams Uni component magma, Binary Phase diagrams in understanding crystal-melt equilibrium–An-Ab, Or-Ab, Di-An, Eutectic & solid solution series, Ternary phase diagrams: Di-Ab-An, An-Di-Fo, An-Ab-Or. Magma generation in crust and mantle, their emplacement and evolution,</p>	12
<p>Unit 3: Magmatism in different tectonic settings Magmatism in the oceanic domains (MORB, OIB), Magmatism along the plate margins (Island arcs/continental arcs), Alkaline magmatism, Mafic Intrusion, Continental Flood Basalt</p>	12
<p>Unit 4: Thermodynamics & classification of igneous rocks Introduction to thermodynamics & different Laws; Phase Rule: Phase, Component, Degree of Freedom, classification of igneous rocks based on physical, mineralogical and chemical attributes; IUGS and CIPW classification schemes; TAS diagram; magma generation and differentiation; Bowen's reaction principle and its petrological significance.</p>	12
<p>Unit 5: Petrogenesis of Igneous rocks Petrogenesis, Origin & tectonic settings of I-, S-, A- type granites, Komatites, Granitoids, Basalt, Gabbros, Anorthosite, Kimberlites, Lamprophyres, Peridotite, Andesite & Carbonatites.</p>	12

Books Recommended:

- *Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.*
- *Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.*
- *Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.* *Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.*
- *McBirney, A. R. (1984). Igneous Petrology. San Francisco (Freeman, Cooper & Company) and Oxford (Oxford Univ. Press),*
- *Myron G. Best (2001). Igneous and Metamorphic Petrology, K. G. Cox, J. D. Bell. (1979). The Interpretation of Igneous Rocks. Springer/Chapman & Hall.*
- *Bose M.K. (1997). Igneous Petrology. G W Tyrrell. (1926). Principles of Petrology. Springer.*

**Practical
Semester III****Major – 5 (MJ - 5) IGNEOUS PETROLOGY****Credit – 4****FM= 100 marks****Lectures – 60 x 2= 120 Hours****Practical****Marks Distribution**

1. Experiments from 1	20
2. Experiments from 2	20
3. Experiments from 3	20
4. Class record	20
5. Viva Voce	20

Total=100**Suggested Practical:****IGNEOUS PETROLOGY**

1. Megascopic identification of igneous rocks.
2. Thin Section study of acid, basic and ultramafic rocks.
3. Plotting of rock compositions in classification diagrams (IUGS and CIPW classification schemes; TAS diagram)

Semester IV

Major – 6 (MJ - 6) SEDIMENTARY PETROLOGY**Credit – 4****FM= 100****Lectures – 60 Hours****T= 100 {75Ext. +25 Int.}****Instructions:**

- There will be two groups 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 of **short answer type** of **5 marks each**.
- **Group B** will contain **descriptive type six questions** of **15 marks** each, out of which **any four are to answer**.

Course Objective:

The primary objective of the course is:

- The students will get to know the different types of sedimentary, metamorphic rocks and fundamentals of sedimentary and metamorphic petrology.
- The students will be able to understand the texture, structures and process of their formation.
- The primary objective of the course of metamorphic petrology is to introduce fundamental understanding of processes, reaction, mineral assemblages formed in different protoliths during metamorphism.

Learning outcomes:

After successfully completing this course, the students will be able to:

- understanding of the processes involved in the formation of sedimentary & metamorphic rocks, their textures, structures, classifications.
- to identify, describe and classify rocks using hand specimens and in thin sections.

Skills to be Learned:

- Identify and study various types sedimentary rocks in field and under microscope
- Can understand the difference between various types of sedimentary rocks
- Know the Process and control of physico-chemical and compositional control on metamorphism of rocks.
- Correlating tectonic setting with metamorphism.

COURSE CONTENT:

Unit	Topic	Total no. of Lectures
Unit 1: Origin of sediments		12
Weathering and sedimentary flux: Physical and chemical weathering, soils and their types and paleosols.		
Unit 2: Sediment granulometry		12
Grain size scale, particle size distribution, Environmental connotation; particle shape and fabric, Grain size scales Udden-Wentworth and Krumbein (phi) scale, particle size distribution, Environmental		

connotation; particle shape and fabric, components and classification of limestone & sandstones	
Unit 3: Sedimentary textures, structures and environment Fluid flow, sediment transport and sedimentary structures: Types of fluids, Laminar vs. turbulent flow, Particle entrainment, transport and deposition, Sedimentary facies and their types, Sedimentary textures, types and its significance, Sedimentary Structures, types and its significance - Primary and syn-sedimentary structures.	12
Unit 4: Varieties of sedimentary rocks Siliciclastic rocks: Conglomerates, sandstones, mudrocks. Carbonate rocks, controls of carbonate deposition, components and classification of limestone, sandstones, dolomite and dolomitisation	12
Unit 5: Diagenesis Process of formation of sedimentary rocks: sediment generation, transportation, deposition, lithification, Concepts of diagenesis, Stages of diagenesis, Compaction and cementation	12

Books Recommended:

- Prothero, D. R., & Schwab, F. (2004). *Sedimentary geology*. Macmillan.
- Tucker, M. E. (2006) *Sedimentary Petrology*, Blackwell Publishing.
- Collinson, J. D. & Thompson, D. B. (1988) *Sedimentary structures*, Unwin- Hyman, London.
- Nichols, G. (2009) *Sedimentology and Stratigraphy Second Edition*. Wiley Blackwell.
- Rollinson, H. R. (2014). *Using geochemical data: evaluation, presentation, interpretation*. Routledge. Raymond, L. A. (2002). *Petrology: the study of igneous, sedimentary, and metamorphic rocks*. McGraw- Hill Science Engineering.

Semester IV

Major – 7 (MJ - 7) METAMORPHIC PETROLOGY**Credit – 4****FM= 100****Lectures – 60 Hours****T= 100 {75Ext. +25 Int.}****Instructions:**

- There will be two groups 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 of **short answer type** of **5 marks each**.
- **Group B** will contain **descriptive type six questions** of **15 marks** each, out of which **any four are to answer**.

Course objective:

The primary objective of the course of Economic Geology is

- to introduce fundamental aspects of origin, mode of occurrences and the distribution of ore deposits to the students.

Learning outcomes:

After successfully completing this course, the students will be able to:

- On completion of the course the students are expected to gain knowledge about various economic minerals, their processes of formation, mode of occurrence and uses.

Skills to be Learned:

- To know the basic concepts of the processes of the formation of the ore deposits
- To know the different types of ore deposits in India and in various parts of the world Spatio-temporal distribution of the different kinds of mineral deposits in India

COURSE CONTENT:

Unit	Topic	Total no. of Lectures
Unit 1: Metamorphism: controls and types.	Definition of metamorphism. Factors controlling metamorphism Types and agents of metamorphism - contact, regional, fault zone metamorphism, impact metamorphism.	12
Unit 2: Metamorphic facies and grades	Index minerals, Chemographic projections, Metamorphic zones. Grade of metamorphism and isogrades. Concept of metamorphic facies and grade, Mineralogical phase rule of closed and open system, Structure and textures and classification of metamorphic rocks and significance.	12
Unit 3: Metamorphism and Tectonism	Relationship between metamorphism and deformation, Metamorphic mineral reactions (prograde and retrograde)	12

Unit 4: Migmatites and their origin Migmatites and its origin, Metasomatism and role of different fluids in metamorphism	12
Unit 5: Metamorphic rocks, types, tectonic setting of Schists, Gneisses, Khondalites, Charnockites, Blueschists and Eclogites	12

Books Recommended:

- *Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.*
- *Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.*
- *Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.*
- *Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.*
- *Yardley, B. W., & Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Earth Science Series.*

Semester IV**Major – 8 (MJ – 8) (Practical) Sedimentary & Metamorphic Petrology****Credit – 4****Lectures – 60 x 2 =120 Hours****P = 100 marks****Practical****Marks Distribution**

1. Sedimentary Petrology Experiment:	30
2. Metamorphic Petrology Experiment	30
3. Field Report	20
4. Practical record & Viva Voce	20

Total=100**Suggested Practical****MJ 6: Sedimentary & Metamorphic Petrology**

1. Study of important Sedimentary rocks in hand specimens and thin sections
2. Megascopic and microscopic study (textural and mineralogical) of different metamorphic rocks,
3. Graphic plots for petrochemistry and interpretation of assemblages: ACF, AKF & AFM diagrams.

MINOR PAPERS**SEMESTER I****Geology-MN 1A: Introductory Geology****(Credits: Theory-03, Practicals-01)****MN-1A: Theory****Credit: 03 Lectures: 45****Marks: 75** (End Semester Examination=60, Semester Internal Examination=10, Class Performance & Attendance =05) **Pass Marks (Internal + End Semester): = 30*****Instruction to Question Setter for******Semester Internal Examination (SIE 10 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.*

End Semester Examination (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.*

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

Course Objective:

The primary objective of the course is:

- To provide student the fundamental ideas about igneous rocks.
- The students will get to know the different types of sedimentary, metamorphic rocks and fundamentals of sedimentary and metamorphic petrology.
- The students will able to understand the texture, structures and process of their formation.

Learning outcomes

After successfully completing this course, the students will be able to understand:

- This course helps the students to understand how to use structures and appreciate the dynamic nature of the Earth's lithosphere.
- The students will learn the skills of identifying different structures.

Skills to be Learned

- Know basic terminologies and concepts in structural geology
- Get familiar with clinometers and measure dip and strike;
- Significance of folds and faults
- Evaluate the geological significance of joints and unconformity;
- Can understand the difference between various types of sedimentary rocks
- Know the Process and control of physico-chemical and compositional control on metamorphism of rocks.

COURSE CONTENT:**Unit 1:****(10-Lectures)**

Holistic understanding of dynamic planet 'Earth' through Geology, Introduction of various branches of Earth Sciences, Application of Geology in various fields.

Unit 2:**(10-Lectures)**

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:

Type of Dam/Reservoir, Tunnel, Bridges.

Unit 3:

(05-Lectures)

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

Unit 4:

(10-Lectures)

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,

Sedimentary: Weathering and Erosion, a process of formation

Metamorphic: agents and types of metamorphism

Unit 5:

(10-Lectures)

Fossils and their application: Definition, processes, modes of preservation and uses, application of

Fossils, Gondwana fossils and their types.

Reference Books:

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

MN-1A:Practical**Credit: 01 Lectures: 30 (15X2)*****Instruction to Question Setter for******End Semester Examination (ESE):***

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

<i>Experiment</i>	<i>= 15 marks</i>
<i>Practical record notebook</i>	<i>= 05 marks</i>
<i>Viva-voce</i>	<i>= 05 marks</i>

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

Reference Books

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

SEMESTER III

GEOLOGY- MN-1B: Essentials of Geology, Rocks & Minerals
(Credits: Theory-03, Practicals-01)
MN-1B: THEORY
Credit: 03 Lectures: 45
Marks: 75 (End Semester Examination=60, Semester Internal Examination=10, Class Performance & Attendance =05) **Pass Marks (Internal + End Semester): = 30**
Instruction to Question Setter for
Semester Internal Examination (SIE 10 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.*

End Semester Examination (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.*

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

Course Objective:

This course aims in helping the students:

- To know the basic of geology, its scope and its various branches
- This course will emphasize the knowledge on the solar system and planets, interior of Earth, Plate Tectonics
- Learn the basics of crystallography and its application to optical mineralogy;
- Understand the fundamental concepts of crystal structure, morphology and its application to mineral sciences. Optical mineralogy part will help the student to understand microscopic techniques applicable to mineralogical and petrographic studies.

Learning Outcomes:

After successfully completing this course, the students will be able to understand:

- The aim of this course is to study the major mineral groups, their occurrences, physical, chemical and crystallographic properties and their possible uses in industry.
- Focus is given on the physical and chemical properties of minerals, from macroscopic to microscopic.
- The course will investigate how geologic materials and processes influence mineral occurrence, stability, and composition.

Skills to be Learned

- Problem-solving skills and creativity thinking
- The ability to recognize and understand complex patterns systems

COURSE CONTENT:
Unit 1:
(10-Lectures)

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:
(10-Lectures)

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: (10-Lectures)

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

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

Unit 4: (10-Lectures)

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. Nature of light and principles of optical mineralogy, Isotropic & Anisotropic, Birefringence, Interference color, Extinction, Twinning and its types
Introduction to the petrological microscope and identification of common rock-forming minerals

Unit 5: (05-Lectures)

Rocks: Definitions and types, Basics of rock formation.

Igneous rock: texture and Structure, magma: Origin and Composition, Bowen's reaction series and magmatic differentiation.

Sedimentary rocks: the process of formation, texture and Structure.

Metamorphic rocks: Agents and types of metamorphism, texture and Structure.

Reference Books:

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

MN-1B: Practical**Credit: 01 Lectures: 30(15X2)*****Instruction to Question Setter for******End Semester Examination (ESE):***

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

<i>Experiment</i>	<i>= 15 marks</i>
<i>Practical record notebook</i>	<i>= 05 marks</i>
<i>Viva-voce</i>	<i>= 05 marks</i>

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

Reference Books:

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

MDC (Multidisciplinary Course): GEOLOGY

SEMESTER I/II/III

MDC-1/2/3: GEOLOGY

(Credits: Theory-03 Lectures-45)

Marks: 75 (End Semester Examination=75
No Internal Examination

Pass Marks: = 30

Instruction to Question Setter for

End Semester Examination (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.

COURSE CONTENT:

Unit-I:

Introduction to geology and its scope, Earth and solar system: origin, size, shape, mass, density and its atmosphere. A brief account of various theories regarding the origin and age of the earth; Brief idea of interior of earth and its composition. Earthquakes: types, origin, nature of seismic waves, their intensity and magnitude scale; Volcanoes: types, products and causes of volcanism, Plate Tectonics & its types with example

Unit-II:

Introduction to Structural Geology, Elementary idea of bed, dip and strike, Fold, Fault, joints, unconformity: its types & recognition in the field. Principle of stratigraphy, Stratigraphy of Gondwana, Vindhyan & Cuddapah supergroup & its type area; Geological Time Scale, definition of Fossils and Mode of preservation condition of fossilization and significance of fossils.

Unit-III:

Introduction to Mineralogy, Definition and characters of mineral. Common physical properties of minerals- Talc, Gypsum, Calcite, Fluorite, Apatite, Orthoclase, Quartz, Topaz, Corundum, Diamond, Muscovite, Biotite, Hypersthene, Olivine, Hornblende. Optical properties of minerals.

Unit-IV:

Magma: definition, composition, types and origin; Forms of igneous rocks; textures, structure & classification of igneous rocks. Classification, textures and structures of sedimentary rocks, Definition of metamorphism; Type of metamorphism. Factors, zones, grade & facies of metamorphism, textures and structures of metamorphic rocks.

Unit-V:

Concept of ore and ore deposits, ore minerals and gangue minerals; Tenor, cutoff grade; Origin, mode of occurrence & distribution of Metallic and non-metallic ore minerals in India- Iron, Copper, Aluminium, Gold, Lead, Zinc, Chromite & Manganese. Coal: origin, types & distribution, Petroleum: origin, occurrence & distribution.

Reference Books:

- *Earth Materials- Introduction to Mineralogy and Petrology, Cornelis Klein and Anthony Philpotts, Cambridge University Press, 2013.*
- *Understanding Earth (Sixth Edition), John Grotzinger and Thomas H. Jordan, 2010, W.H. Freeman and company, New York.*
- *Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley Billings, M. P. (1987) Structural Geology, 4th edition, Prentice-Hall.*
- *Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.*
- *Mason, B. (1986) Principles of Geochemistry. 3rd Edition, Wiley New York.*
- *Rollinson, H. (2007) Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.*
- *Energy and the Environment by Fowler, J.M 1984. McGraw-Hill*
- *Global Energy Perspectives by Nebojsa Nakicenovic 1998, Cambridge University Press.*
- *Energy Resources and Systems: Fundamentals and Non-Renewable Resources by Tushar K. Ghosh and M. A. Prelas. 2009, Springer*
- *Introduction to Wind Energy Systems: Hermann-Josef Wagner and Jyotirmay Mathur. 2009, Springer.*
- *Renewable Energy Conversion, Transmission and Storage. Bent Sorensen, 2007, Springer.*