

ANNEXURE - A

**INSTITUTE OF GEOLOGY, UNIVERSITY OF THE PUNJAB
LAHORE**

**Course Outline of B.S. Applied Geology 4 Years
Under Annual System**

FIRST PROFESSIONAL

Sr. No.	Course	Marks		
		Theory	Practical	Total
I.	A. Islamic Studies B. Pak Studies	60+40	-	100
II.	English	100	-	100
III.	Mathematics I	100	-	100
IV.	Physics I	75	25	100
V.	Chemistry I	75	25	100
VI.	Mineralogy	75	25	100
VII.	General Geology	100	-	100
VIII.	Paleontology	75	25	100
IX.	Geomorphology	75	25	100
X.	Fieldwork I	50	50	100
TOTAL:		825	175	1000

SECOND PROFESSIONAL

Sr. No.	Course	Marks		
		Theory	Practical	Total
I.	Communication Skills & Technical Report Writing	100	-	100
II.	Mathematics II	100	-	100
III.	Physics II	75	25	100
IV.	Chemistry II	75	25	100
V.	Stratigraphy of Pakistan	75	25	100
VI.	Computing & Geostatistics	50	50	100
VII.	Survey & Mapping Techniques	50	50	100
VIII.	Petrology	75	25	100
IX.	Nuclear Geology	75	25	100
X.	Structural/Petroleum Geology	75	25	100
XI.	Fieldwork II	50	50	100
TOTAL:		800	300	1100

THIRD PROFESSIONAL

Sr. No.	Course	Marks		
		Theory	Practical	Total
I.	Geology & Tectonics of Pakistan	75	25	100
II.	Sedimentology	75	25	100
III.	Economic Geology	75	25	100
IV.	Remote Sensing & GIS	75	25	100
V.	Micropaleontology	75	25	100
VI.	Geophysics	75	25	100
VII.	Geochemistry	75	25	100
VIII.	Engineering Geology & Hydrogeology	75	25	100
IX.	Advance Mineralogy and Applied Lab Techniques	75	25	100
X.	Environmental Geology	75	25	100
XI.	Fieldwork III	50	50	100
TOTAL:		800	300	1100

FOURTH PROFESSIONAL

Sr. No.	Course	Marks		
		Theory	Practical	Total
I.	Special Paper I	75	25	100
II.	Special Paper II	75	25	100
III.	Special Paper III	75	25	100
IV.	Special Paper IV	75	25	100
V.	Thesis	400		400
TOTAL:		700	100	800

Detail of Courses of BS Applied Geology 4 Years
Institute of Geology, PU, Lahore

FIRST PROFESSIONAL

1. Islamic Studies and Pak Studies

Mark 60+40

(۱) عَنْ عَبْدِ اللَّهِ ابْنِ عُمَرَ بْنِ الْخَطَّابِ رَضِيَ اللَّهُ عَنْهُمَا قَالَ سَمِعْتُ رَسُولَ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ يَقُولُ بَنِي الْإِسْلَامِ عَلَى خَمْسٍ شَهَادَةٌ أَنْ لَا إِلَهَ إِلَّا اللَّهُ وَأَنَّ مُحَمَّدًا عَبْدُهُ وَرَسُولُهُ وَأَقَامُ الصَّلَاةَ وَآتَى الزَّكَاةَ وَحَجَّ الْبَيْتِ وَصَوْمَ رَمَضَانَ. (مُتَّفَقٌ عَلَيْهِ)

(۲) عَنْ أَبِي هُرَيْرَةَ رَضِيَ اللَّهُ عَنْهُ قَالَ سَمِعْتُ رَسُولَ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ يَقُولُ: مَا نَهَيْتُكُمْ عَنْهُ فَاجْتَنِبُوهُ وَمَا أَمَرْتُكُمْ بِهِ فَاتُّوْا مِنْهُ مَا اسْتَطَعْتُمْ فَإِنَّمَا أَهْلَكَ الَّذِينَ مِنْ قَبْلِكُمْ كَثْرَةُ مَسَائِلِهِمْ وَاخْتِلَافِهِمْ عَلَى أَنْبِيَائِهِمْ.

(مُتَّفَقٌ عَلَيْهِ)

(۳) عَنِ الْحَسَنِ ابْنِ عَلِيٍّ رَضِيَ اللَّهُ عَنْهُمَا قَالَتْ حَفِظْتُ مِنْ رَسُولِ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ دَعَا مَا يُرِيكَ إِلَى مَا لَا يَرِيكَ

(رَوَاهُ التِّرْمِذِيُّ وَغَيْرُهُ)

(۴) عَنْ أَبِي هُرَيْرَةَ رَضِيَ اللَّهُ عَنْهُ قَالَ: قَالَ رَسُولُ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ: مِنْ حُسْنِ الْإِسْلَامِ الْمَرْءُ تَرَكَهُ مَا لَا يُغْنِيهِ.

(رَوَاهُ التِّرْمِذِيُّ وَغَيْرُهُ)

(۵) عَنْ أَنَسِ بْنِ مَالِكٍ رَضِيَ اللَّهُ عَنْهُ النَّبِيُّ

حصہ اول اسلامیات

کتاب و سنت

(الف) قرآن مجید

۱۔ فضائل قرآن، ۲۔ سورۃ حجرات، ۳۔ متن اور ترجمہ کے

ساتھ

۴۔ سورۃ الفرقان: وعباد الرحمن..... تا کیون لڑا

(آیت ۶۳ تا ۷۷)

(ب) سنت:

۱: سنت کی اہمیت، ۲۔ بیس منتخب احادیث۔ متن و ترجمہ کے

ساتھ

صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ قَالَ: لَا يُؤْمِنُ أَحَدُكُمْ حَتَّى يُحِبَّ الْآخِيَةَ مَا يُحِبُّ لِنَفْسِهِ.

(مُتَّفَقٌ عَلَيْهِ)

(٦) عَنْ أَبِي هُرَيْرَةَ رَضِيَ اللَّهُ عَنْهُ أَنَّ رَسُولَ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ قَالَ: مَنْ كَانَ يُؤْمِنُ بِاللَّهِ وَالْيَوْمِ بِاللَّهِ وَالْآخِرِ فَلْيُكْرِمْ خَيْرًا أَوْ لِيَصْنُتْ وَمَنْ كَانَ يُؤْمِنُ بِاللَّهِ وَالْيَوْمِ بِاللَّهِ وَالْآخِرِ فَلْيُكْرِمْ جَارَهُ وَمَنْ كَانَ يُؤْمِنُ بِاللَّهِ وَالْيَوْمِ بِاللَّهِ وَالْآخِرِ فَلْيُكْرِمْ صَيفَهُ.

(مُتَّفَقٌ عَلَيْهِ)

(٧) عَنْ أَبِي هُرَيْرَةَ رَضِيَ اللَّهُ عَنْهُ أَنَّ رَجُلًا قَالَ لِنَبِيِّ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ: لَا تَغْضَبْ فَرَدَّدَ مَرَارًا قَالَ لَا تَغْضَبْ.

(رَوَاهُ الْبُخَارِيُّ)

(٨) عَنْ أَبِي ذَرٍّ رَضِيَ اللَّهُ عَنْهُ رَسُولَ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ قَالَ: اتَّقِ اللَّهَ حَيْثُمَا كُنْتَ وَاتَّبِعِ السَّبِيلَ الْحَسَنَةَ تَمْحُهَا وَخَالِقِ النَّاسَ بِخُلُقٍ حَسَنٍ.

(رَوَاهُ التِّرْمِذِيُّ)

(٩) عَنْ أَبِي مَسْعُودٍ عَقَبَهُ بَنُ عَمْرِو الْأَنْصَارِيِّ الْبُذْرِيُّ رَضِيَ اللَّهُ عَنْهُ قَالَ: قَالَ رَسُولُ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ: إِنَّ مِمَّا أَذْرَكَ النَّاسُ مِنْ كَلَامِ النَّبِيِّ أَوْلَى إِذَا لَمْ تَسْتَحْ فَأَفْعَلْ مَا شِئْتَ.

(رَوَاهُ الْبُخَارِيُّ)

(١٠) عَنْ سُفْيَانَ بْنِ عَبْدِ اللَّهِ رَضِيَ اللَّهُ عَنْهُ قَالَ قُلْتُ يَا رَسُولَ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ قُلْ لِي فِي الْإِسْلَامِ قَوْلًا لَا أَسْأَلُكَ عَنْهُ أَحَدًا غَيْرَكَ قَالَ: قُلْ آمَنْتُ بِاللَّهِ ثُمَّ اسْتَغْفِرُ.

(رَوَاهُ مُسْلِمٌ)

(١١) عَنْ جَابِرِ بْنِ عَبْدِ اللَّهِ الْأَنْصَارِيِّ رَضِيَ اللَّهُ عَنْهُمَا. إِنَّ رَجُلًا سَأَلَ رَسُولَ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ فَقَالَ أَرَأَيْتَ إِذَا صَلَّيْتُ الْمَكْتُوباتِ وَصُمْتُ رَمَضَانَ وَاحْلَلْتُ الْحَلَالَ حَرَمْتُ الْحَرَامَ وَلَمْ أَزِدْ عَلَى ذَلِكَ شَيْئًا أَذْخُلُ الْجَنَّةَ قَالَ نَعَمْ

(رَوَاهُ مُسْلِمٌ)

(١٢) عَنْ خَالِدِ بْنِ عَمْرٍو الْقُرَشِيِّ عَنْ أَبِي حَازِمٍ عَنْ سَهْلِ أَنَّ النَّبِيَّ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ وَعَظَ رَجُلًا إِنْ هَدَى فِي الدُّنْيَا يَجِبْكَ اللَّهُ وَازْهَدْ فِيمَا أَيْدِي النَّاسِ يُجِبْكَ النَّاسُ.

(رَوَاهُ ابْنُ مَاجَةَ)

(١٣) عَنْ أَبِي سَعِيدٍ الْخُدْرِيِّ رَضِيَ اللَّهُ عَنْهُ أَنَّ رَسُولَ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ قَالَ: لَا ضَرَرَ وَلَا ضِرَارَ

(رَوَاهُ ابْنُ مَاجَةَ)

(١٤) عَنْ أَبِي عَبَّاسٍ رَضِيَ اللَّهُ عَنْهُمْ أَنَّ رَسُولَ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ قَالَ: لَوْ يُعْطَى النَّاسُ بِدَعْوَاهُمْ لَا دَعَى رِجَالُ أَمْوَالِ قَوْمٍ وَدِمَاءِ هُمْ لَكِنِ الْبَيِّنَةُ عَلَى الْمُدْعَى وَالْيَمِينُ عَلَى مَنْ أَنْكَرَ.

(رَوَاهُ الْبَيْهَقِيُّ)

(١٥) عَنْ أَبِي سَعِيدٍ الْخُدْرِيِّ رَضِيَ اللَّهُ عَنْهُ قَالَ سَمِعْتُ رَسُولَ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ يَقُولُ: مَنْ رَأَى مِنْكُمْ مُنْكَرًا فَلْيُغَيِّرْهُ بِيَدِهِ فَإِنْ لَمْ يَسْتَطِعْ فَبِلِسَانِهِ فَإِنْ لَمْ يَسْتَطِعْ فَبِقَلْبِهِ وَذَلِكَ أَضْعَفُ الْإِيمَانِ.

(رَوَاهُ مُسْلِمٌ)

iv تعمیر و کردار: تعارف و تمہید، اسلام میں تعمیر کردار کی اہمیت۔

(الف) اخلاق حسنہ:

تقویٰ اور اخلاص، صدقہ، سخاوت، دیانتداری، رحم، عدل و انصاف (سماجی و معاشی انصاف)، احسان، ایفائے عہد، ایثار، سادگی، رواداری، احترام آدمیت، اخوات، والدین اور بزرگوں کا احترام، کسب حلال۔

(ب) فضائل اخلاق، تعارف، تکرار و تمہید:

تکبر، بہتان طرازی، غربت، منافقت، خوشامد، کفر، ناپ تول میں کمی،

(ج) تہذیب انسانی کی تعمیر میں اسلام کا حصہ:

امت مسلمہ، احیاء اسلام کی تحریکیں اور ہمارا مستقبل،

حصہ دوم مطالعہ پاکستان

مقاصد: پاکستان کا ایسا مطالعہ جس سے طلباء میں ماضی پر فخر۔ حال کے لیے جوش و خروش اور مستقبل پر مستحکم اعتماد ہو اور ان کا یہ پختہ عقیدہ ہو کہ قومی استحکام اور ملی ترقی کے لیے وہ سب کچھ کرنا فرض ہے۔ جس کے وہ اہل ہیں۔ تعمیر وطن کے لیے یہ ایک جذباتی احساس ہی نہ ہو بلکہ نظریہ پاکستان کے علمی تعمیر اور تحریک پاکستان کو صحیح معنوں میں سمجھنے کا نتیجہ ہو۔

یہ کورس افراد پاکستان کی ذہنی تربیت کا ایسا درسی مواد ہو۔ جو کہ پاکستانی تشخص، اپنی روایات پر یقین کو مستحکم بنائے اور عملی زندگی میں ایسے تعمیری رویہ کی جانب راہنمائی کرے جو کہ قوم کو اسلامی اقتدار سے قریب تر کرنے میں معاون ہو۔ مختصراً یہ قومی پالیسی کے نصب العین ”پاکستان کے اسلامی نظریہ کو قائم رکھنا، تقویت دینا اور مستحکم کرنا اور علمی تربیت کے ذریعے اس کو انفرادی

(۱۶) عَنْ أَبِي عَبَّاسٍ رَضِيَ اللَّهُ عَنْهُ: أَنَّ رَسُولَ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ قَالَ: إِنَّ اللَّهَ تَجَاوَزَ نَبِيَّ عَنْ أُمَّتِي الْحَظَاءُ وَالْيَسِيَانِ وَمَا اسْتُغْرِيهُوَ عَلَيْهِ. (رَوَاهُ ابْنُ مَاجَه)

(۱۷) عَنْ أَبِي عَمْرٍو رَضِيَ اللَّهُ عَنْهُمَا قَالَ: أَخَذَ رَسُولُ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ بِمَنْكِبِي فَقَالَ كُنْ فِي الدُّنْيَا كَأَنَّكَ غَرِيبٌ أَوْ غَا بِرُسَيْلٍ. (رَوَاهُ الْبُخَارِيُّ)

(۱۸) عَنْ عَبْدِ اللَّهِ بْنِ عَمْرٍو وَبْنِ الْعَاصِ رَضِيَ اللَّهُ عَنْهُمَا قَالَ: رَسُولُ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ لَوْ يُؤْمِنُ أَحَدُكُمْ حَتَّى يَكُونَ هَوَاهُ تَبَعًا لِمَا جِئْتُ بِهِ.

(أَرْبَعِينَ نَوْرِي)

(۱۹) عَنْ عَبْدِ اللَّهِ بْنِ عَمْرٍو رَضِيَ اللَّهُ عَنْهُ قَالَ: قَالَ رَسُولُ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ الْمُسْلِمُ مَنْ سَلِمَ الْمُسْلِمُونَ مِنْ لِسَانِهِ وَيَدِهِ وَالْمُهَاجِرُ مَنْ هَجَرَ مَا نَهَى اللَّهُ عَنْهُ. (رَوَاهُ الْبُخَارِيُّ)

(۲۰) عَنْ أَنَسٍ رَضِيَ اللَّهُ عَنْهُ قَالَ: قَالَ رَسُولُ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ لَا يُؤْمِنُ أَحَدٌ حَتَّى يَكُونَ أَحِبَّ إِلَيْهِ مِنْ وَلَدِهِ وَوَالِدِهِ وَالنَّاسِ أَجْمَعِينَ.

(متفق عليه)

۱۱۔ دین اسلام: آیات قرآنی اور احادیث کی روشنی میں۔

۱۔ توحید، ۲۔ رسالت، ۳۔ آخرت، ۴۔ نماز، ۵۔ روزہ، ۶۔ زکوٰۃ،

۷۔ حج، ۸۔ جہاد،

۱۱۱۔ اسوۂ حسنہ: حضور صلی اللہ علیہ وسلم کی سیرت طیبہ کا مطالعہ بطور:

۱۔ رہبر مذہب، ۲۔ معلم و محرک تعلیم، ۳۔ مبلغ داعی، ۴۔ سپہ سالار،

۵۔ مدبر و شام، ۶۔ سربراہ خاندان، ۸۔ تاجر، ۹۔ عابد، ۱۰۔ زاہد

یونٹ نمبر ۵: پاکستان کے حصول کے لیے جدوجہد پاکستان کے

لیے مسلم عوام کی جدوجہد

۱: اقلیتی صوبوں کے مسلمانوں کا کردار اور ایثار

۲: سرحد، بلوچستان، سندھ، کشمیر اور بلوچستان کے مسلمانوں کا حصہ

یونٹ نمبر ۶: تحریک پاکستان میں:

۱: علماء اور مشائخ

۲: ادیب اور صحافی

۳: طلباء اور خواتین کا حصہ

یونٹ نمبر ۷: قیام پاکستان کے اہم واقعات

۱: ہندوستان میں مسلم کش فسادات، مشرقی پنجاب میں قتل عام

۲: نہری پانی اور اثاثوں کی تقسیم

۳: ریاستوں کے الحاق کا مسئلہ، حیدرآباد، جونا گڑھ اور کشمیر

یونٹ نمبر ۸: پاکستان میں نظام اسلام کے نفاذ کی کوشش

۱: قرارداد مقاصد

۲: ۱۹۵۶ء-۱۹۶۲ء اور ۱۹۷۳ء کے آئین کی اسلامی دفعات

۳: نفاذ شریعت، ابتدائی اقدامات

۴: ہماری منزل - مکمل اسلامی معاشرہ کا قیام

یونٹ نمبر ۹: ارض پاکستان

(الف) جغرافیائی وحدت - محل وقوع، جغرافیائی اہمیت، دہی و

شہری علاقے

(ب) قدرتی وسائل

(ج) زراعت (د) صنعت (ه) درآمد و برآمد

(و) افرادی قوت

یونٹ نمبر ۱۰: پاکستان اور عالم اسلام

یونٹ نمبر ۱۱: علامہ اقبال کے پچاس منتخب اشعار - از صد شعر اقبال - از

صوفی غلام مصطفیٰ تبسم

اور قومی زندگی کا شعار بنانا، کی تفسیر ہو۔

یونٹ نمبر ۱: نظریہ پاکستان

قیام پاکستان کے اغراض و مقاصد۔

۲: نظریہ پاکستان

تعریف و توصیف نظریہ پاکستان اقبال اور قائد اعظم کے

ارشادات کی روشنی میں۔

یونٹ نمبر ۲: برصغیر میں مسلم معاشرہ کی تشکیل اور ارتقاء۔

یونٹ نمبر ۳: نظریہ پاکستان کا تاریخی پہلو۔

۱: برصغیر میں مسلم دور حکومت۔

۲: مسلم اقتدار کا زوال اور نشاۃ ثانیہ کی کوششیں۔

۳: ملی اصلاحی تحریکیں (شیخ احمد سرہندی)۔ (شاہ ولی اللہ اور

مالعد)

۴: تعلیمی کوششیں، علی گڑھ۔ دیوبند، ندوۃ، انجمن حمایت اسلام

اور دیگر تعلیمی ادارے، سندھ مدرسہ، اسلامیہ کانچ پشاور

۵: سیاسی جدوجہد، آئینی اصلاحات اور مسلمان، جداگانہ

انتخاب، تحریک خلافت،

یونٹ نمبر ۴: تحریک پاکستان

۱: مسلم قومیت و قومی نظریہ کا ارتقاء

۲: ہندوستان کی آزادی کا مسئلہ اور مسلمان

۳: علامہ اقبال کا خطبہ الہ آباد

۴: انتخابات ۱۹۳۷ء اور انگریز حکومتوں کا رویہ

۵: قرارداد پاکستان

۶: ہندو اور انگریز کا رد عمل

۷: ۱۹۴۶ء کے انتخابات اور انتقال اقتدار

2. English**(Marks 100)**

Learning major elements of English grammar by using principles of linguistic analysis. Identifying the main morphological and syntactic constructions in English including parts of speech; basic sentence structure; tense, aspect, and mood; clause type; negation; complex sentences; thematic systems; the relations between sentences in discourse; and ellipsis and coordination.

Use of grammar in context of the structure of English; words (mechanics of word building: base forms, affixes, prefixes, suffixes, as well as derivation and inflection), phrases (the clause/phrase distinction; discussion of nominal clauses, complementizers, and interrogatives), clause and sentence structure, major sentence types (interrogative, imperative, exclamatory) and their differences from one another., punctuation, agreement errors commonly confused and misused words spelling, Reported speech.

Oral communication skills; listening and speaking, expressing ideas/opinions on topics related to students lives and experiences, Participation in class room discussion on contemporary issues.

Reading and writing skills; identifying main idea/topic sentence, note taking and note making, developing a paragraph outline (topic sentence and supporting details)

Vocabulary building skills;

Books Recommended:

1. Eastwood, J. 2004. *Oxford Practice Grammar*. New Ed., with tests and answers. O UP
2. Goatly, A. 2000. *Critical Reading and Writing: An Introductory Course*. London: Taylor & Francis
3. Wallace, M. 1992. *Study Skills*. C UP
4. Fisher, A. 2001. *Critical Thinking*. C UP
5. Hacker, D. 1992. *A Writer's Reference*. 2nd Ed. Boston: St. Martin's
6. Hewing, M. *Advanced Grammar in Use*. New Ed. C UP
7. Murphy, Raymond. *Grammar in Use*. C UP
8. Swan, M. and Walter C. *How English Works*. Oxford: O UP
9. Thomson & Martinet. *Practical English Grammar*

3. Mathematics I**(Marks 100)****Basics of Mathematics**

1. The real number system, Linear equations and inequalities
2. Polynomials , roots of polynomial
3. Functions and its types, Trigonometric functions
4. System of Equations
5. Matrices and Determinants
6. Complex numbers, De Moivre's theorem, simple elementary functions of a complex variable

Differential Calculus

1. Limit and continuity of functions of one variable
2. Geometric meaning of the derivative ,tangent and normal
3. Differentiation of algebraic, trigonometric, logarithmic, exponential and hyperbolic functions
4. Rolle's Theorem, Lagrange's mean value theorem.
5. Curvature and radius of curvature, Circle of curvature
6. Higher derivatives, Some Standard nth derivatives and Leibnitz theorem,
7. Function of several variables, partial derivatives, Euler theorem, Composite functions and Chain rule. Implicit functions, Maxima and Minima of a function of one variable
8. Taylor and Meclaurin's theorems

Integral Calculus

1. Integration by substitution, by parts and by partial fractions.
2. Definite integral and Reduction Formula

Differential Equations

Ordinary Differential Equations first order.

4. Physics I**(Marks 75 + 25)**

- **Vectors:** Includes measurements, vectors Rules for their addition and Multiplication, Divergence Theorem and Stoke's Theorem.
- **Mechanics:** materials and their properties Stress and strain Concept , Theory of Elasticity , Hook's law, Plasticity Tensile and shear strength and concept of Friction

- **Non Relativistic Mechanics:** Newton's Law of motion vector form of Newton Second law and it's applications Conservation of Linear Momentum Fictitious forces
- **Inverse square law Forces:** Newton's Law of Universal Gravitation, Force Between point mass and solid sphere, Kepler's law and prove, Escape Velocity
- **Optics:** Nature and Propagation of light reflection refraction and dispersion of light, lenses and optical instruments, X ray diffraction, Refraction by prism.
- **Conservation of energy** conservation laws in Physics, Definition and Concept, work and energy, power, Potential Energy in a Gravitational Field
- **Fluid Dynamics and Statics:** fluids and Solids, Pressure and Density, Pascal's principal, Archimede's Principal, General concept of fluid flow Equation of Continuity, Bernoulie's Equation Viscosity surface tension
- **Dynamics of a rigid body:** center of mass, Conservation of angular momentum equation of motion of rotating body moment of inertia Equilibrium of rigid bodies' kinetic energy of rotation.

Practical:

- Modulus of Rigidity of a wire by Maxell's needle
- Variation of Photo-Electric current with intensity of incident light
- Young's modulus of a material of a flat spiral spring
- Value of "g" by a Compound Pendulum
- Modulus of rigidity of the material of a plat spiral spring
- Low resistance by Carry Foster's bridge

Books Recommended:

1. Physics for Scientist by Serwar by CBS College Publishing in USA the Dryden Press.
2. Mechanics by Prof. M. H Musaddiq and M. Rafique published by Allied Book Center Urdu Bazar Lahore.
3. Physics by Resnick and Helliday by John Wiley and son's inc united states
4. B.Sc. Physics Practical Manual by M.H Musaddiq
5. Physics by Halliday and Resnick
6. Mechanics by M.H Musaddiq

5. Chemistry I

(Marks 75+25)

An introduction to inorganic chemistry, molecular structure and thermodynamics.

Analytical Chemistry: An introduction to the basic principles of analytical chemistry, with particular emphasis on Law of mass action, solution equilibria, solubility product, common ion effect and classical methods of analysis. General principles of gravimetric and volumetric analysis. Role of indicator and various types of indicators used.

Separation Techniques: Solvent Extraction and different types of chromatographic processes; principle and applications of column chromatography, paper chromatography and thin-layer chromatography.

Spectrochemical Techniques: General theory of Spectroscopy; Flame photometry; Atomic absorption spectroscopy and spectrophotometry; basic principles, instrumental and applications, use of classical and modern computer-controlled instrumentation and techniques, as applied to the acquisition and analysis of experimental data.

The properties, structures and reactions of inorganic compounds with emphasis on transition metal chemistry.

Periodic Table and Periodicity: Gradual developments in Periodic Table; Periodicity in the properties of elements, Advantages and drawbacks of arranging the elements in present form of Periodic Table.

Acids and Basis: Different theories of Acids and bases; Arrhenius theory, Lowery Bronsted theory and Lewis acid-base theory; Strength of acids and bases. pH and pK values.

Practical:

- Volumetric Exercises
- Staining Tests for Calcite, Dolomite, Gypsum.
- Quantitative determination of halide ions by argentometry.
- Determination of Ca and Mg by complexometry.
- Determination of Fe by redox titration methods.
- Determination of water hardness.
- Determination of Fe and Ni in water and soil.

- **Colorimetric Exercises**

- Determination of Mn, P in rock samples.
- Determination of iron (III) ions by complexing with potassium thiocyanate.

6. Mineralogy

(Marks 75+25)

Introduction: Definition and significance of minerals.

- Crystallography: Crystallization, Internal order in crystals, Crystal Symmetry, Crystallographic notations, Crystal Forms, Crystal systems and crystal classes. Structural complexities and defects in crystals.
- Physical Properties of Minerals
- Crystal Chemistry: Bonding forces in crystals, Crystal with more than one bond types. Some common structure types. Phase equilibrium studies Compositional variation in minerals, Recalculation of Chemical Analysis, Graphic representation of Mineral Composition.
- Optical Mineralogy: Polarized light, double refraction, birefringence, extinction, Introduction to polarizing microscope Microscopic examination of minerals--- Color, pleochroism, absorption, cleavage, R.I. relief, habit, alteration, inclusions, twinning and zoning.
- Systematic Mineralogy: Mineral Classifications, Detailed studies of important members of oxides, sulfides, sulfates, carbonates, halides, tungstaes, phosphates, Silicates and their structural classification.

Practical:

Study of crystal models and natural crystals, their illustrations and drawings. Megascopic identification of common minerals.

Megascopic and microscopic identification of common rock forming minerals. Use of polarizing microscope. Determination of optical properties of common rock forming minerals.

Books Recommended:

1. Rutley's Elements of Mineralogy (1981) By H. H. Read, 26th Edition, Thomas Murby & Co.
2. Manual of Mineralogy (1999) by Cornelis Klein & Cornelius S. Hurlbut, Jr. after J. D. Dana. John Wiley & Sons, Inc.
3. Principles of Mineralogy by William, H.B., 1990, Oxford University Press.
4. Elements of Mineralogy by. Mason B & Berry, L. G. 1968, W. H Freeman and Company.
5. Mineralogy by Perkins, D., 2002, Prentice Hall
6. Minerals and Rocks by Klien, C., 1989, John Wiley & Sons.
7. An Introduction to Rock Forming Minerals by Deer, W.A. Howie, R.A. & Zussman, J., 1992, Longman.
8. Principles of Mineralogy by William, H.B., 1990, Oxford University Press.
9. Mineralogy by Perkins, D., 2002, Prentice Hall
10. Optical Mineralogy by Kerr, P.F., 1959, McGraw Hill.
11. Igneous and Metamorphic Petrology by Best, M.G., 1982, W.H. Freeman & Co.
12. Minerals in Thin Sections by Perkins, D., 200, Prentice Hall.
13. Petrography of Igneous and Metamorphic Rocks by Philpotts, A.R., 1989, Prentice Hall.
14. Atlas of Rock-Forming Minerals in Thin Section by MacKenzie, W.S., Guilford, C.P 1980, John Wiley & Sons.
15. Introduction to Optical Mineralogy by Nesse, W.D., 2003, Oxford University Press.
16. An Atlas of Minerals in Thin Section by Schulze, D.J., 2003,, CD-ROM, Oxford University Press.

7. General Geology

(Marks 100)

Introduction and scope of geology, its importance and relationship with other sciences. Earth as a member of the solar system; its origin, age, composition and internal structure. Minerals and their physical properties. Introduction to rocks. Moon, Earth's neighbors, meteorites, earthquakes and volcanoes. Weathering and erosion and related land forms. Primary sedimentary, igneous and metamorphic structures. Introduction of folds, faults, joints, cleavage, foliation, lineation and unconformities. Isostasy; Introduction to plate tectonics, mountain building processes.

Study of relief features with the help of models and topographic maps. Simple geological maps and drawing of cross-sections. Use of field instruments viz, Brunton Compass/Clinometer.

Books Recommended:

1. Principles of Physical Geology by Holmes, A., 1978, Nelson.
2. Foundation of Structural Geology by Park, R.G., 1983, Blackie
3. Elementary exercises upon Geological Maps by Platt, J.I, latest Ed., Thomas Murby & Co.
4. An introduction of Geological Structures and Maps by Bennison, G.M., latest Ed., Edward Arnold.
5. Physical Geology by Plummer, McGeary & Carlson, 2005.
6. Lab. Manual for Physical Geology by Jones, Norris. W., Johnes, Charles E., 2005, McGraw Hill.
7. How does Earth work: Physical Geology and Process of Science by Smith, G., and Pun, A., 2006, Prentice Hall.
8. The 3D Mapping of Geological Structures by McClay, K.R., 1987, Open University Press.

8. Paleontology**(Marks 75+25)**

Evolution of life and its paleontological evidences, taxonomy Fossils and their significance; modes of fossilization. Geological time scale, Study of morphology, range and broad classification of major invertebrate phyla viz. coelenterata, brachiopoda, mollusca, arthropoda (trilobite) and echinodermata (echinoidea) Protozoa. Introduction to micro fossils. Introduction to paleobotany. Evolution and classification of vertebrates.

Practical:

Megascopic identification and description of fossils related to phyla studied in Paleontology theory class.

Books Recommended:

1. Invertebrate Fossils by Moore, R.C., Lalicker, C.G. & Fischer, A.G., 1952, McGraw Hill
2. Principles of Paleontology by Raup, D.M. & Stanley, S.M., 1985, W.H. Freeman & Co.
3. Vertebrate Paleontology by Romer, A.S., 1966, University Chicago Press.

9. Geomorphology**(Marks 75+25)**

Geomorphic cycles and associated landforms. Uses and interpretation of topographic maps, aerial photographs and satellite imageries. Interpretation of geological structures. Glaciers and their erosional and depositional land forms. Geological work of wind. Its types, drainage pattern, stream meandering and development of flood plains. Occurrence and geological work of groundwater. The erosional and depositional work of sea, development of coastal land forms. Landforms produced by tectonics and volcanic activity.

Practical:

Terrain analysis using topographic maps, aerial photographs and satellite imageries. Techniques of photogeological mapping.

Books Recommended:

1. Geomorphology of Earth Surface Processes and Form by Aharna, V.K., 1986, McGraw Hill.
2. Geomorphology by Chorley, R.J., 1984, Methuen.
3. Image interpretation in Geology by Drury, S.A. 1986, Allen & Unwin.
4. Remote Sensing & Image Interpretation by Lillis, T.M. & Kiefer, R.W., 1987 John Wiley & Sons.
5. Principles of Geomorphology by Thornbury, W.D., 1991 John Wiley & Sons.
6. Process Geomorphology by Ritter, Kochel & Miller, 2002.

10. Fieldwork I**(Marks 100)**

Guided geological excursion of about 12 day's duration with the following objectives.

- Observation of Physical features of the earth surface and their representation on the topographic sheet.
- Identification of ubiquitous lithologies and rock types.
- Fauna collection and recognition.
- Recognition of minerals in natural condition and their collection.
- Visit to mining sites and mineral industry.

Every student will maintain a field notebook. He will carry out sampling, labeling and book entries. This notebook will be presented at the time of Viva Voce examination, which should be properly signed by the concerned teacher/s in the field.

At the end of field excursion, every student will submit a field report and will be examined by viva voce.

Evaluation		
Field report based on field notes	During Field Evaluation	Viva Voce
50%	20%	30%

II PROFESSIONAL

1. Communication Skills & Technical Report Writing (Marks 100)

Oral Communication Skills: (Listening and Speaking), Comprehend and use English inside and outside the classroom for social and academic purposes

Reading and Writing Skills: Distinguishing between facts and opinions, Recognizing and interpreting the tone and attitude of the author, Recognizing and interpreting the rhetorical organization of a text, Generating ideas using a variety of strategies e.g. mind map, Developing an outline for an essay, Writing different kinds of essay (descriptive and narrative)

Language and Linguistics; Morphology (Word forms & structures) and Phonology (Sounds of English)

Principles and practice of writing, with attention to critical thinking and analytical reading. Includes discussion skills, library usage, research techniques, and an introduction to literature.

Preparing for interviews (scholarship, job, placement for internship, etc.)

Preparing technical documents such as proposals, instructions and reports. Writing formal letters, Writing different kinds of applications (leave, job, complaint, etc.)

Oral presentation skills (prepared and unprepared talks), Preparing a CV.

Critical Reading: Advanced reading skills and strategies building on Foundation of English in I Prof. expository (description, argumentation, comparison and contrast). Read the lines (literal understanding of text), read between the lines (to interpret text), read beyond the lines (to assimilate, integrate knowledge etc.)

Academic Writing: Advanced writing skills and strategies building on Foundations of English I & II in semesters I and II: Writing well organized academic text with topic/thesis statement/supporting details, write narrative, descriptive, argumentative essays and reports (assignments)

Books Recommended:

- Akmajian, A; Demers, R. A; Farmer, A. K. and Harnish, R. M. 2001. *Linguistics: An Introduction to Language and Communication*. 4th Ed. Massachusetts: MIT
- Coulthard, Malcolm. 1985. *An Introduction to Discourse Analysis*. New Ed. London: Longman
- Gee, J. A. P. 2005. *An Introduction to Discourse Analysis*
- Ellen, K. 2002. *Maximize Your Presentation Skills: How to Speak, Look and Act on Your Way to the Top*
- Hargie, O. (ed.) *Handbook of Communications Skills*
- Mandel, S. 2000. *Effective Presentation Skills: A Practical Guide Better Speaking*
- Aaron, J. 2003. *The Compact Reader*. New York: Bedford
- Axelrod, R. B and Cooper, C.R. 2002. *Reading Critical Writing Well: A Reader and Guide*
- Barnet, S. & Bedau, H. 2004. *Critical Thinking, Reading and Writing: A Brief Guide to Writing*. 6th Ed.
- Gardner, P. S. 2005. *New Directions: Reading, Writing and Critical Thinking*
- Goatly, A. 2000. *Critical Reading and Writing: An Introductory Course*. London: Taylor & Francis
- Jordan, K. M. and Plakans, L. 2003. *Reading and Writing for Academic Success*
- Jordon, R. R. 1999. *Academic Writing Course*. C UP.
- Smith, L. C. 2003. *Issues for Today: An Effective Reading Skills Text*

2. Mathematics II**(Marks 100)****Differential Equations**

1. The Ordinary Differential Equations of second order with constant coefficients.
2. Determination of complimentary functions and particular integrals

Numerical Analysis:

1. Estimation of errors, Solution of polynomials and interpolation.
2. Computer Application of Numerical Techniques.

Vector Analysis

Scalar and vector quantities, algebra of vectors. Dot and cross product of vectors. Differentiation and integration of vector function. Multiple integrals. Gradient of a scalar point functions. Divergence and curl of a vector field, Equations of the straight line, the plane and the sphere. Complex variables: function of a complex variables, Derivative of function of a complex variables, analytic function and Cauchy Reimann Equations, Cauchy's Theorem .Laurent's expansion and theory of Residues.

Fourier Series and Laplace Transform

Introduction to Periodic functions, Fourier Series, convergence of Fourier Series, , Fourier Series of functions with arbitrary periods, , Fourier Series for even and odd foundations, Laplace Transform, derivatives and integrals, Transformation of ordinary differential equations and their solutions. Differentiation and integration of Transforms.

Potential Theory

Laplace Equations in Polar and Cylindrical Coordinate

Power functions through seismic velocities, trigonometry through cliff erosion, and integration through sediment accumulation

3. Physics II**(Marks 75+25)**

Heat and Thermodynamics: Concepts of temperature and heat, temperature- dependent properties and processes, heat transfer; laws relating heat and other forms of energy

Radioactivity. Natural Radioactivity, Nature of alpha particles Beta rays Gamma rays. Radioactive series laws of radioactive decay, Half life and Artificial radioactivity.

Overview of the universe, evolutionary development of the universe beginning with the Big Bang through structure formation and galaxy formation, star formation and stellar life cycles, planet formation, the planetary system, and life in the universe, the Earth in the solar system.

Vibrations and waves. Ferroelectricity, Piezoelectricity and Pyroelectricity. Electricity and magnetism topics of particular relevance to geophysical exploration. Basic physics underlying different applied geophysical methods such as gravity method, seismic reflection and refraction methods.

Practical:

1. Vertical Distance between two points and height of an inaccessible object
2. Stopping power of α -Particles
3. Methods of producing good practices in data gathering, recording, and analysis. Characteristics of common instrumentation and basic circuits.

Books Recommended:

1. Physics for Scientist by Serwar published by CBS College Publishing in USA the Dryden Press.
2. Mechanics by M. H Musaddiq and M Rafique published by Allied Book Center Urdu Bazar Lahore
3. Physics by Resnick and Halliday by John Wiley and son's inc united states
4. B.Sc. Physics Practical Manual by M.H Musaddiq
5. Physics by Halliday and Resnick
6. Mechanics by M.H Musaddiq

4. Chemistry II**(Marks 75+25)**

Thermodynamics: Various forms of First law of thermodynamics, Specific heats at constant volume and constant pressure, Second law of thermodynamics, adiabatic changes, reversible and ir-reversible process.

Radioactivity: Different types of radiations; radioactive elements; Artificial radioactivity; radio isotopes and their applications. Radioisotopes and their uses; age determination of sulphide deposits.

Advanced Instrumental Analysis: Fundamental aspects of modern instrumental methods. Spectroscopic methods: UV visible and atomic absorption Spectroscopy flame and plasma emission methods. Chromatographic methods; liquid and gas chromatography. Mass spectroscopy. Laboratory: Analysis of inorganic and organic samples using spectroscopic electrochemical and chromatographic instrumental methods.

Law of Mass action and its application to solubility of calcite, solubility of amorphous silica, transformation of feldspars to kaolinite, formation of Gypsum/anhydrite, Evaporation of sea water.

Phase rule and the following systems: Kyanite - andalusite-sillimanite and Leucite – silica

Thermodynamics and formation of Galena, Wollastonite and Malachite

Practical:**Flame photometric Exercises**

Determination of sodium and potassium in different types of mineral water samples. Chemical analysis of limestone, Gypsum, iron ore, chromite. Interpretation of chemical analysis of Gypsum and chromite etc

Books Recommended:

1. Theoretical principles of Inorganic geochemistry
2. Solutions, Minerals and Equilibria by Harper and Fow
3. Introduction to Geochemistry by Krauskopf
4. Standard methods of chemical Analysis by Furman

5. Stratigraphy of Pakistan**(Marks 75+25)**

Principles of stratigraphy; laws of superposition and faunal succession. Classification and nomenclature of stratigraphic units: lithostratigraphic unit, biostratigraphic unit and chronostratigraphic unit. Geological time scale. Stratigraphic Code of Pakistan. General Stratigraphic correlation.

Outline of regional geology of Pakistan. Study of Stratigraphic type sections of Khewra gorge, Nammal gorge, Chichali gorge, Murree Brewery gorge and Bara nala. Type sections of Rawalpindi Group and Siwaliks.

Introduction, history, concept and significance of sequence stratigraphy.

Books Recommended:

1. Principles of stratigraphy by Weller, J.M., 1962, Harper Brothers.
2. Stratigraphy of Pakistan by Shah, S.I. 1977, Geological Survey of Pakistan.
3. Principles of Sedimentology and Stratigraphy by Boggs, S., 20001, Prentice Hall.
4. Stratigraphic Code of Pakistan, () Geological Survey of Pakistan.
5. Silici-clastic Sequence Stratigraphy in well Logs, Cores and Outcrops by Van Wagoner, J.C, et.al, 1990, AAPG Meth Expl. Ser. No. 7.
6. Sea level changes an integrated approach by Wilgus, B.S. et.al., 1988, SEPM.
7. Seismic Stratigraphy: Application to H-Carbon Exploration by Payton, C.W., 1977, AAPG Mem. 26.
8. Sequence Stratigraphy and Facies Association by Posamentier, H.W., et. Al., 1993, Blackwell.
9. Sequence stratigraphy by Emery, D., & Myers, K.J., 1996, Oxford, Blackwell

Practical:

Preparation of Stratigraphic columns and their correlation.

6. Computing & Geostatistics**(Marks: 50+50)**

Theory behind computers. Operating Systems. What do geologists use computers for? Review of common productivity packages---spreadsheet, word processor, presentation, image analysis, Communication, database and GIS. Planning, executing, writing up, and presenting a geologic study. Internet: Internet resources for geologists. Algorithms and Flowcharts, Methods of finding, gathering, managing, and evaluating geoscience information. Application of statistical methods to geology including, descriptive data analysis. correlation and regression, tests of hypotheses, trend surface analysis, analysis of variance, nonparametric statistics and time series analysis. Finding data sources, creating valid data sets and visualizing data, simulating geostatistical data.

Practical:

Exercises on use of computer packages and web interfaces in Geology, 3D Geologic Visualization Packages, Statistical packages etc.

7. Survey & Mapping Techniques**(Marks: 75+25)**

- Principals of map preparation, various types of map projections, Topographic maps with reference to Pakistan, Importance of Maps.
- Geological Maps, Principles of geological maps, representation of geological information of topographic maps. Specialized geological maps.
- Concept of third dimension, subsurface extension of rock bodies. Inference from out crop, geological and topographic information.
- Bore-holes, lithological logging and heavy mineral suites, concept and principles of correlation.
- Pitting, tunneling and drifts in bedded deposits and veins, Drilling data and various types of logging.
- Principles of preparation of three dimensional block models.

Practical:

- Study of topographic maps, scales and nature of projections. Preparation of survey maps with the help of chain surveying and plane table surveying.
- Preparation of geological maps on the basis of topographic sheets. Plotting of various geological information on maps.
- Bore-hole data interpretation.
- Preparation of subsurface geological correlation maps.
- Preparation of block diagrams and models.

8. Petrology**(Marks 75+25)**

- Composition, origin, differentiation and evolution of magma. Mineralogical and chemical characteristics, Textures and Classification of Rocks. Origin, emplacement, and modification of igneous rocks. Oceanic and continental rocks and their characterization, Petrography and occurrence of the following series: Tholeiitic and alkali-olivine basalt. Basalt – andesite series. Study of granites, granodiorite, syenite, carbonatite mafic and ultramafic rocks. Lamprophyres. Facies analysis of volcanic rocks.
- Introduction to Tectonomagmatic environments, Magmatic differentiation --- Granites. Characteristics of ophiolites. Modes of common igneous rocks.
- Introduction to phase diagrams. Metamorphic rocks; Metamorphism and grades of metamorphism, Metamorphic Facies Regional and Thermal Metamorphism. Metamorphic diffusion and differentiation. Study of thermal and regional metamorphism of argillaceous, calcareous and arenaceous rocks. ACF and AKF diagrams. Metamorphism in relation to plate tectonics. Development of textures and structures.
- The composition, lithification, diagenesis and classification of Sedimentary rocks, emphasizing the interpretation of provenance, sedimentary processes, and post depositional modifications. Petrography of common varieties of sedimentary rocks.

Practical:

Megascopic and microscopic identification and description of ubiquitous igneous and metamorphic rocks.

Books Recommended:

1. Igneous and metamorphic petrology by Best, M.G., 2002, Black Well.
2. Petrology of Igneous and Metamorphic rocks, By Hyndmann, D.W., 1995, McGraw Hill.
3. Igneous Petrogenesis by Wilson, M. 1989, Unwin Hyman.
4. Petrology: Igneous, sedimentary & metamorphic by Blat, H. Tracy, R. & Owens, D., 2005, W.H. Freeman & Co.
5. Metamorphism and Plate Tectonic Regimes by Ernst, W.G., 1975, Hutchison & Ross, Inc.
6. Metamorphic Petrology by Turner, F.J. 1981, McGraw Hill.
7. Introduction to Igneous and metamorphic Petrology, Winter, J.K., 2001, Prentice Hall.
8. Petrogenesis of Metamorphic Rocks by Winkler, H.G.F., 1987, Springer – Verlag.
9. Petrogenesis of Metamorphic Rocks by bucher, K. & Frey, B., 1994, Springer-Verlag.
10. Igneous Rocks: A Classification and Glossary : Recommendations of the IUGS sub commission, Maitre, R.W., Le Bas, M.J., Streckeisen, A., Zanettin, B & Bonin, B. (eds), 2005.
11. Igneous, Sedimentary, and Metamorphic Petrology by Blatt, H., Tracy, R., & Owens, B., 2005, W.H. Freeman & Co.
12. Metamorphic Petrology by Miyashiro, A., 1994, Oxford University Press.

9. Nuclear Geology**(Marks: 75+25)**

Some physics and chemistry of Uranium. The basics of radioactivity. Theory and Nature of radioactive and stable isotopes, their applications in geology. Principles of Radioactive Dating, Dating of geologic materials by utilizing natural radioactivity. Radioactive minerals. Depleted and Enriched Uranium, Nuclear power, mass to energy, Environment, health and safety issues. Uranium resources, Geology of Uranium Deposits and their classification. Characterization of Pakistan Uranium Deposits.

Practical:

Isochrons and Pateau dates, Study of Radioactive Minerals, radiation measurement.

Books Recommended:

1. Faure, Gunter (1986) *Principles of Isotope Geology*, 2nd edition. Wiley, New York.
2. Dickin, Alan P. (1995) *Radiogenic Isotope Geology*, Cambridge University Press.
3. U. Aswathanarayana (1985) *Principles of Nuclear Geology*, Oxonian Press, New Delhi

10. Structural/Petroleum Geology**(Marks 75+25)**

Stress: concepts, classes, ellipsoid, Mohr circle of stress. Strain: concept, measures of strain, classes, ellipse and ellipsoid, stress-strain diagram. Factors, which control the mechanical behavior of materials. Folds: morphology, classification based on morphology, geometry, vergence and mechanics of fold formation.

Faults: terminology, slip and separation, geometrical and genetic classification and recognition of faults. Structures in compressional and extensional regimes, transform faults and fault mechanics.

Joints: terminology, geometry and classification.

Foliation: terminology, classification and relationship with bedding.

Lineation: terminology and classification.

Unconformity: concept, classification and recognition.

The nature of petroleum hydrocarbons, their origin, migration and accumulation. Source sediments, reservoir rocks, and trapping mechanism for oil and gas. Prospecting and exploration of oil and gas. Basic concepts of exploration seismology; geochemical methods; drilling and well logging. Reservoir characteristics, drive mechanism, energy and pressure maintenance. Secondary and enhanced recovery. Recent advances in reservoir engineering. Petroleum basins and world distribution of oil and gas with emphasis on Pakistan and Middle-East.

Practical:

Map exercises and construction of geological and balanced cross-sections. Orthographic projections (geometrical exercises): dimension calculations. Introduction to stereographic projections: plotting a plane, a line on a plane. Determining of the rake of a line: plunge and bearing from rake. True and apparent dip. Determining the intersection of two planes. Pole to a plane; angles between lines and planes.

Preparation of various kinds of subsurface maps, e.g., isopachs, isochore, isoliths etc. Preparation of fence diagrams. Visits to well / drilling sites.

Books Recommended:

1. Foundation of structural Geology by Park, R.G., 1983, Blackie.
2. Structural Geology of Rocks and Regions by Davis, G.H. & Reynolds, S.J. 1996, John Wiley & Sons.
3. Laboratory Exercise Book in Structural Geology by Ghauri, A.K., 1989, National Centre of Excellence in Geology, University of Peshawar.
4. An Introduction to Geological Structures and Maps by Bennisen, G.M., 1975, Edward Arnold.
5. Structural Geology by Twiss, R.J. & Moores, E.M., 1995, W.H Freeman & Co.
6. Petroleum Geology by North, F.K., 1985, Allen & Unwin.
7. Geology of petroleum by Iversen, A.I., 1970, W.H. Freeman & Co.
8. Geology and Tectonics of Pakistan by Kazmi, A.H. & Jan, M.Q., 1997, Graphic Publishers.
9. Geology of Pakistan by Bender, F.K. & Raza, H.A. (eds.) 1995, Gebruder Borntraeger.
10. Hydrocarbons from Coal by Law B.E., & Rice, D.D., 1993, AAPG studies in Geology # 38.
11. Principles of petroleum Development Geology by London, R.C., 1996, Prentice Hall.
- 12.

11. Fieldwork II**(Marks: 100)**

Supervised Field Trip of 15 days duration. Field work will have the following objectives.

- Study of classical stratigraphic sections of Pakistan with reference to stratigraphic code of Pakistan.
- Study of Geomorphologic features and weathering effects.
- Study of field characters of common sedimentary, metamorphic and igneous rocks including color, texture, contact relationships etc and collection of samples.
- Section measurements in a sedimentary terrain

Every student will maintain a field note book. He will carry out sampling, label them and make book entries. The note book will be presented at the time of Viva Voce examination, which should be properly signed by the concerned teacher/s in the field.

At the end of field excursion every student will write field report on the basis of field data and microscopic studies in the lab.

Evaluation

Field report based on field notes

During Field Evaluation

Viva Voce

50%

20%

30%

THIRD PROFESSIONAL

1. Geology & Tectonics of Pakistan

Geological framework and Principal geological divisions of Pakistan:

The Chagai and Ras Koh area, The Dalbandin Trough, The Ras Koh Geanticline and Ras Koh-Mirjawa Flysch Belts, The Mashkel depression, The Makran-Khojak-Pishin Flysch zone, The Makran, Khojak, and Pishin Flysch segment, The Fold and Thrust belts of Pakistan, Indus basin, Tethyan belt, The Sub, Lesser and Higher Himalayas, The KIA complex, The Karakorum block, The Hindu Kush elements.

Precambrian to Quaternary Sedimentary sequence of Pakistan:

Igneous and metamorphic rocks of Pakistan: Igneous and metamorphic rocks of the Tethyan belt, Indo-Pakistan plate, south of MMT, south of MCT, Alkaline igneous province, Post Hercynian events, KIA Complex, Karakorum Block, Eastern Hindukush, Elements of the Indian Craton, South of the Himalayas, Fold and thrust belt, Chagai-Ras Koh Volcanic Arc.

Tectonics and structure:

Plate boundaries and regional fabric, Tectonic zones, Shield elements and buried ridges, Indus Basin, The Fold and thrust belt, Khuzdar block, Sulaiman block, The Bela-Waziristan Ophiolite Zone, The Chagai-Ras Koh Volcanic Arc, The Makran-Khojak-Pishin Flysch Zone.

Palaeogeographic and geodynamic evolution of Pakistan:

Books Recommended:

1. Tectonics by Moores, E.M. & Twiss, R.J., 1995, W.H. Freeman and Co.
2. Global Tectonics by Keary, P. & Vine, F.J., 1996, Blackwell.
3. Plate Tectonics: How It works by Cox, A. & Hoot, R.B., 1986, Blackwell
4. The Evolving continents by Windley, B.F., 1984, John Wiley & Sons.
5. Geology of Pakistan Ed.: Bender, Friedrich; Raza, Hilal A. 2006, Gebr. Borntraeger Verlagshandlung, Science Publishers, Stuttgart.

Practical:

Macroscopic and Microscopic Studies and geochemical data analyses of rock suites of various tectonic settings of Pakistan.

2. Sedimentology

(Marks 75+25)

Introduction to Sedimentology, origin, transportation and deposition of sediments. Texture of sedimentary rocks and their statistical parameters. Sedimentary structures, their classification, morphology and significance. Classification and description of sedimentary rocks. Provenance of sediments. Diagenesis Concepts of sedimentary facies and facies associations. Physico-chemical controls of the sedimentary environments. Diagnostic features of fluvial, lagoonal, lacustrine, deltaic, tidal and marine environments. Tectonic controls of sedimentation.

Practical:

Grain size analysis of sediments and sedimentary rocks. Megascopic and microscopic study of sedimentary rocks. Separation and identification of heavy minerals. Study of sedimentary structures.

Books Recommended:

1. Sand and sandstone by Pettijohn, F.J., Potter, P.E. & Siever, R., 1973, Springer Verlag.
2. Principles of Sedimentology by Friedman, G.M., & Sanders, J.E. 1978, John Wiley & Sons.
3. Depositional Sedimentary Environments by Reineck, H.E. & Singh, I.B., 1980, Springer – Verlag.
4. Carbonate Sedimentology by Tucker, M.E. & Wright, V.P, 1990, Blackwell.
5. Sedimentary Environment and facies by Reading, H.G., 1986, Blackwell
6. Applied Sedimentology by Selly, R.C., 1988, Chapman & Hall.
7. Petrology of Sedimentary Rocks by Boggs, Jr. S. 1992, Merrill Publishing Co.
8. Sedimentary Rocks by Pettijohn, F.J., 1975, Harper and Row.
9. Sedimentary Geology by Prothero, D., & Schwab, F., 1996, W.H. Freeman & Co.

3. Economic Geology

(Marks 75+25)

Introduction economic minerals and rocks and their classification. Processes of formation of economic mineral deposits: magmatic segregation, hydrothermal solution, metasomatism, sedimentation, evaporation, residual and mechanical concentration and metamorphism. Relationship of mineral deposits to plate tectonic settings. Introduction of geological exploration / prospecting. Brief

description of hydrocarbons, coal, gemstones, copper, lead, zinc, iron, gold, chromite, manganese, salt, gypsum, bauxite, sulfur, barite, fluorite, clays, phosphorite, building stones, industrial rocks and radioactive minerals and rocks with special reference to deposits in Pakistan.

Practical:

Identification and description of ores and industrial minerals/rocks. Grade and reserve estimation of deposits.

Books Recommended:

1. Directory of Mineral Deposits of Pakistan, by Zaki, A., 1969. Geological survey of Pakistan.
2. Ore Deposits by Park, C.F. & MacDiarmid, R.A., 1970, W.H. Freeman & Co.
3. Economic Mineral Deposits by Janssen, M.L. & Bateman, A.M., 1972, John Wiley & Sons.
4. Mineral Prospecting Manual by Chausier, J.B., 1987, North Oxford Academic Press
5. An Introduction to ore Geology by Evans, A.M., 1987, Blackwell.
6. Atlas: Economic Mineral Deposits by Dixon, C.J. 1979, Chapman Lordin & Hall.
7. Metallogeny and Mineral Deposits of Pakistan by Kazmi, A.H. & Abbas, S.G., 2001, Orient Petroleum Inc.
8. Handbook of Exploration Geochemistry, Govett, G.J.S. (ed), 1995, Elsevier
9. Ore Deposit Geology by Edward, R. & Atkinsons, K., 1986, Chapman and Hall.

4. Remote Sensing & GIS

(Marks 75+25)

An overview including background, history, need of remote sensing. Recent developments in remote sensing. Electromagnetic spectrum, Source and sensor. Physical terms and units, Radiometric terms and units. Thermal properties. Interaction of different wave-lengths with the earth's surface and vegetation.

Aerial Photographs: Films and cameras. Scale and corrections, displacement. Distance, area, height and slope measurements. Techniques of Photogeological mapping. Relation to topographic maps. Photo-interpretation drainage, vegetation, soils and rocks (with their structural attitude).

Aerial and satellite imagery: multi-spectral scanners. Sideways-looking airborne radar. Introduction to Digital Image Processing and GIS. Analysis of digital and raster data. Introduction to Earth Resource Satellites. Classification of landforms, land-cover and land use. Statics in field of geology and geomorphology.

Practical:

Terrain analysis using topographic maps, aerial photographs and satellite imageries. Techniques of photogeological mapping. Digital analysis of satellite data.

Books Recommended:

13. Geomorphology: Earth Surface Processes and form by Aharna, V.K., 1986, McGraw Hill.
14. Geomorphology by Charley, R.J., 1984, Methuen.
15. Image Interpretation in Geology by Drury, S.A., 1986, Allen & Unwin.
16. Remote Sensing and Image Interpretation by Lilles, T.M. and Kiefer, R.W., 1987, John Wiley & Sons.
17. Monitoring the Earth by Vita-Finzi, C., 2003 Oxford University Press.
18. Fundamentals of Geographic Information Systems by Demers, M.N., 2002, John Wiley & Sons.
19. Remote Sensing and Image Interpretation by Lillesand, T.M., et.al., 2003.
20. Concepts and Techniques of Geographic information system by Yeung, Lo.C.P. & Lal, A.K., 2003, Prentice Hall.
21. Aerial Photography and Image Interpretation, Kiser, J.D., Paine, D.P., 2003, John Wiley & Sons.

Remote Sensing: Principles & Applications by Panda, B.C., 2005, Viva Books Pvt. Ltd.

5. Micropaleontology

(Marks 75+25)

Introduction to foraminifera, Bryozoa, ostracoda, Conodonts, Algae, Pollen and Spores, organic walled microplanktons and nano-fossils. Principles of bio-stratigraphy and bio-stratigraphic zones. Bio-stratigraphic techniques and procedures. Tertiary biostratigraphy with special reference to Pakistan.

Practical:

Basic Micro-Paleontological and bio-stratigraphic techniques. Morphological and taxonomic studies of selected microfossils.

Books Recommended:

1. Microfossils by Brasier, M.D., 1980, Allen and Unwin.
2. Invertebrate Fossils by Fischer, G.A. and Moore, R.C., latest Ed., McGraw Hill.
3. Introduction to marine Micropaleontology by Haq & Boersma, 1980, Elsevier.
4. Paleontology by Tucker, V.C.T. and Noeld, E.W., 1985, Pergamon Press.
5. Planton stratigraphy by Balli & Saunders, 1986, Oxford University Press.

6. Geophysics**(Marks: 75+25)**

Definition and relation of geophysics with other sciences. Classification and brief description of various branches of geophysics such as seismology, geomagnetism, geoelectricity, tectonophysics, gravimetry, geo-thermy and geodesy.

Introduction to various geophysical techniques for exploration of mineral deposits; oil and gas and engineering works. Geophysical data processing. Earthquake seismology and geodynamics of Earth. Ground Penetrating Radar, Borehole Geophysics.

Practical:

Analysis and interpretation of geophysical data and computer modeling.

Books Recommended

1. Applied geophysics by Telford, W.M., Geldart, C.P., Sheriff, R.E., & Keys, D.A., 1976, Cambridge University Press.
2. Introduction to Geophysics by Garland G.D., 1971, W.B. Saunders Co.
3. Seismic Exploration by Al-Sadi, H.N, 1980, Birkhauser Verlag.
4. Introduction to Geophysical Prospecting by Dobrin, M.B. & Savit, C.H., 1988, McGraw Hill.
5. An Introduction to Geophysical Exploration by Kearey, P., & Brooks, M., 1991, Osney Mead.
6. Basic Exploration Geophysics by Robinson, E.S. & Coruh, C., 1988, John Wiley & Sons.
7. Geophysical Methods in Geology by Sharma, P.V., 1987, Elsevier.

7. Geochemistry**(Marks:****75+25)**

Development of Geochemistry as a discipline. Composition of meteorites. Origin and cosmic abundance of elements. Geochemical structure of the earth. Geochemical classification of elements. Polymorphism and pseudomorphism. Geochemical cycle; mobility and dispersion of elements under different geochemical environments. Introduction to geochemistry of igneous, metamorphic and sedimentary rocks. Geochemical anomalies and their application in mineral exploration.

Practical:

Geochemical sampling and analytical techniques. Processing and interpretation of geo-chemical data.

Books Recommended:

1. Introduction to Geochemistry by Krauskopf, K.B, 1967, McGraw Hill
2. Principles of Geochemistry by Mason B., 1966, John Wiley & Sons.
3. Geochemistry in Mineral Exploration by Rose, A.W., Hawkes, H.H. & Webb, J.S, 1983, Whitstable Litho Ltd.,
4. Inorganic Geochemistry by Henderson, P., 1982, Pergmon Press Ltd.
5. Geochemistry by Brownlow, A.H., 1996, Prentice Hall.
6. Geochemistry by Beaumont, E.A., & Foster, N.H., 1988, AAPG special Bull, Publication No. 8

8. Engineering Geology & Hydrogeology**(Marks:75+25)**

Rock and soil mechanics and its application in civil engineering. Rock mass characteristics. Elastic properties and rocks. Geological factors and strength of rocks. Classification of rocks. Study of geological factors in relation to the construction of buildings and foundations, roads, highways, tunnels, dams and bridges. Application of geophysical methods. Case histories of important engineering projects (small & Mega) in Pakistan. Site investigation for engineering projects. Construction materials. Landslides, their causes and prevention.

The hydrologic cycle. Formation of aquifer system and types. Occurrence and movement of groundwater. Hydrologic properties of rocks and their measurements. Fluctuation of groundwater levels and causes. Recharge and discharge of groundwater. Groundwater exploration by geological, hydrogeological and geophysical methods and remote sensing techniques. Well hydraulics, tube well drilling techniques, designing, development and pumping tests. Waterlogging and causes of water table

declination. Groundwater chemistry, salinity, quality analysis and deterioration of water quality. Groundwater resources of Pakistan.

Practical:

Determination of physical and geotechnical properties of soils and rocks. Visits to the engineering projects.

Inventory and monitoring of groundwater. Preparation of water table and piezometric surface maps. Study and preparation of hydrogeologic maps. Graphical presentation of chemical analysis of groundwater. Field visits to drilling sites.

Books Recommended:

1. Field Hydrogeology by Brassington, R., 1988, John Wiley & Sons.
2. Groundwater Hydrology by Todd, D.K., 1995, John Wiley & Sons.
3. Groundwater Resource Evaluation by Walton, W.C., latest Ed., McGraw Hill.
4. Introduction to Groundwater by Michael P., 1985, George Allen & Unwin.
5. Applied Hydrogeology by Fetter, C.W., 1994, MacMillan Pub. Co.
6. Groundwater by Ragunath, H.M., 1992, Wiley Eastern Ltd.
7. Atlas of WAPDA
8. Groundwater Hydrology by Bouwer, H., 1988, McGraw Hill.
9. Hydrology and Groundwater Resources of NWFP by Kruseman, G.P., 1988, WAPDA
10. Engineering Geology by Beavis, F.C., 1985, Blackwell.
11. Geology for Engineers by Blyth, F.G.H. & De Frietes, M.H., 1960, Butter & Tonner Ltd.
12. Geology and Engineering by Legget, R.F., 1962, McGraw Hill.
13. Fundamentals of Engineering ?Geology by Bell, F.A.G., 1983, Butter Worth.
14. Measuring Engineering Properties of Soil by Wray, W.K., 1986, Prentice Hall.
15. Engineering Geology by Goodman, R.E., 1993, John Wiley & Sons.

9. Advance Mineralogy & Applied Lab Techniques

(Marks: 50+50)

Physical and Chemical Properties of Minerals. Relationship between the structure chemistry and properties of Silicates, carbonates, oxides, sulfides, and phosphate.

Wet chemical analysis techniques (such as AAS, ICP emission, ICP-MS), **solid state analysis techniques** (such as XRF, XRD, Thermal Analysis, SEM, TEM, EPMA, laser ablation-ICP-MS, INAA), **separation analysis techniques** (such as GC, HPLC, IC), **spectral analysis techniques** (such as NMR, MS, IR, UV/VIS-spectrometry)

Practical:

Microscopic identification of the common rock forming minerals in thin section, using transmitted and reflected light microscopy. Identification of common ceramic refractory and slag minerals in thin section.

Books Recommended:

1. Mineralogy for students by Battey, M.H., 1981, Longman.
2. Mineralogy by Berry and Masson, 1983, W.H. Freeman & Co.
3. Mineralogy by Perkins, D., 2002, Prentice Hall
4. Minerals in Thin Sections by Perkins, D., 2000, Prentice Hall.
5. Petrography of Igneous and Metamorphic Rocks by Philpotts, A.R., 1989, Prentice Hall.
6. Atlas of Rock-Forming Minerals in Thin Section by Mackenzsie, W.S. Guilfird, C. P., 1980, John Wiley & Sons.
7. Introduction to Rock Forming Minerals by Deer, W.A., Howie, R.A. & Zussaman, J., 1992, Longman.
8. Instrumental Analysis, 1986, Christian G. D. & O'Reilley, J.E. 2nd Ed. Allyn & Bacon, Massachussetts.
9. Principles of Instrumental Analysis 2005, by Douglas A. Skoog, F. James Holler, Timothy A. Nieman.
10. Undergraduate Instrumental Analysis, 6th Ed. by James W. Robinson, Eileen M. Skelly Frame, George M. Frame II.
11. Quantitative Chemical Analysis, 6th Ed. by Daniel C. Harris

10. Environmental Geology**(Marks 75+25)**

Introduction to Environmental geology. Management of natural resources. Air pollution and global climatic changes, environmental controls for erosion, desertification and coastal degradation. Geological hazards such as floods, landslides, earthquakes, volcanoes, glaciers and shoreline processes, their remedial measures. Environmental impact of mining, dams, reservoirs, highways, their assessment and controls. Cleaner sources of energy.

Industrial pollution, waste disposal, groundwater contaminations, river lake and marine pollution and their impact on human health. Geological aspects of human health. Trace elements and health hazards.

Practical:

Sampling and analysis of air, water, soil and rocks.

Books Recommended:

1. Environmental Geology by Keller, E.A., latest Ed., Chales E. Merrill Publishing Co.
2. Earthquake Risk and Damage by Liu, B.C., 1981, Westview.
3. Environmental Geology by Montgomery, C.W., 2005, McGraw Hill.
4. Radio propagation and remote Sensing of the Environment by Armanel, N.A., Polyakove, V.M, 2005, CRC Press.

11. Fieldwork III**(Marks 100)**

Guided geological excursion of three-week duration preceded by lectures on advanced techniques and methods of field geology necessary for detailed geological maps and interpretation.

Geological excursion will be comprised of the following:

One week mapping camps to prepare a geological map of a sedimentary area.

One week mapping camp to prepare a geological map of igneous/ metamorphic area.

Visiting dam sites, well sites, mines and quarries and acquiring data regarding bore-hole logging, pits, tunnels and different kinds of drilling etc. Every student will maintain a field notebook. This notebook will be presented at the time of viva voce examination, which should be properly signed by the concerned teacher/s in the field. At the end of this field program, every student will study thin sections for micropaleontological and petrological purposes.

Field report will be the conclusion of extensive field data as well as through lab work and pervasive literature survey.

Evaluation

Field report based on field notes

During Field Evaluation

Viva Voce

50%

20%

30%

FOURTH PROFESSIONAL

Sr. No.	Course	Marks		
		Theory	Practical	Total
I.	Special Paper I	75	25	100
II.	Special Paper II	75	25	100
III.	Special Paper III	75	25	100
IV.	Special Paper IV	75	25	100
V.	Thesis	400		400
	Total	700	100	800

In the IV Prof, students will go for any one of the following twelve areas of specialization. Four courses will be offered in each field of specialization (Groups).

During the first half of the academic year course work and examination will be completed.

During the second half of the academic year, research for thesis including field and laboratory work, data acquisition compilation, thesis writing will be accomplished.

Group-I Mineralogy and Petrology

This comprises the following courses:

1. Geochemistry
2. Igneous Petrology
3. Metamorphic Petrology
4. Sedimentary Petrology
5. Advanced Mineralogy

1. Geochemistry

Classification and distribution of elements. Causes for the diversity in igneous rocks. Geochemical characteristics of igneous rocks as petrogenetic indicators. Processes which modify the composition of primary magmas. Geochemical characteristics of different magma series. Geothermometry. Metasomatism, its types and transfer of material involved.

Lab. I: Characterization of igneous rocks on the basis of their (a) modal and (b) chemical composition. Calculation of normative composition from the major element chemistry of igneous rocks. The use of major and trace element composition of igneous rocks as a means to determine their paleotectonic setting.

Graphical representation of metamorphic mineral parageneses (ACF and AKF diagrams). Parentage of a variety of metamorphic rocks on the basis of their major and trace element geochemistry. The use of mineral chemical data for estimating pressure-temperature conditions of metamorphism.

Books Recommended:

1. Igneous and metamorphic petrology by Best, M.G., 1982, W.H. Freeman & Co.
2. Petrogenesis of Metamorphic Rocks by Butcher, K. & Frey, M. 1994. Springer Verlag.
3. The Interpretation of igneous Rocks by Cox, K.G., Bell J.D. & Pankhurst, R.J., 1979, George Allen & Unwin.
4. Petrology of the Igneous Rocks by Hatch, F.H., Wells, A.K. & Wells, M.K., 1975, Murby.
5. Introduction to Geochemistry by Krauskopf, K.B, 1982, McGraw Hill.
6. Petrology by Nockolds, S.R., Knox, R.W. O.B. & Chinner, G.A., 1978, Cox & Wyman.
7. Using Geochemical Data: Evaluation, presentation and Interpretation by Robinson, 1993, Longman.
8. Geochemistry by Wedepohl, K.H., 1967, Hol, Rinenhart & Winston.
9. Igneous Petrogenesis by Wilson, M., 1989, Academic Press.
10. Geochemistry by Brownlow, A.H., 1996, Prentice Hall.

2. Igneous Petrology

Igneous rock associations. Petrogenesis of igneous rocks. Petrogenic provinces: Basaltic Provinces. Granite–granodiorite provinces and mafic-ultramafic complexes.

Tectonism-magmatism relationship. Igneous activity related to convergent plate boundary and divergent plate boundary environments. Intracontinental hot spots. Continental rift related magmatism.

Collisional and subduction environments and igneous activity. Ophiolites. Mantle-magma systems and source of magma. Physico-chemical factors in magmatic evolution.

Lab. II: Petrographic Study of Rock suits. Modal analyses.

Books Recommended:

1. Igneous Petrology by Hill, A., 1987. Longman Scientific & Technical.
2. Petrology: Igneous, Sedimentary and Metamorphic by Ehlers, E.G. & Bloatt, H.W.H., 1982, W.H. Freeman & Co.
3. Petrology: Igneous and Metamorphic Rocks by Hyndman, D.W., 1972, McGraw Hill.
4. Igneous and metamorphic petrology by Best, M.G. 1982, W.H. 1982, W.H. Freeman & Co.
5. Igneous and metamorphic petrology by Turner, F.J. & Verhoogen, J. 1960, McGraw Hill.
6. Igneous Petrogenesis by Wilson, M. 1989, Unwin Hyman.
7. Igneous Petrogenesis by Carmichael, I.S.E. Turner, F.J. & Verhoogen, J., 1974, McGraw Hill.
8. Igneous Petrology by McBirney, A.R., 1984, Freeman Cooper & Co.
9. Introduction to Igneous and metamorphic Petrology by Winter, J., 2001, Prentice Hall.

3. Metamorphic Petrology

Basic characteristics of metamorphic reactions and role of fluids. Concept of iso-grades and iso-reaction grades. Very low grade and ocean floor metamorphism. cataclastic metamorphism. Metamorphic facies series. P-T gradients, mineralogical characteristics of individual facies, progress metamorphism of pelites, basic rocks and carbonates., high grade metamorphism, anatexis and magmatites. Tectonics of regional metamorphic belts. Paired metamorphic belts. Metamorphic structure of continental crust.

Lab. III: construction and interpretation of ACF and AKF diagrams. Petrographic study of various rocks suites. Mineral and Mineral phase equilibria and P-T conditions.

Books Recommended:

1. Petrology: Igneous, Sedimentary and Metamorphic by Ehlers, E.G. & Blatt, H.W.H., 1982, W.H. Freeman & Co.
2. Igneous and Metamorphic Petrology by Hyndman, D.W., 1972, McGraw Hill.
3. Igneous and Metamorphic Petrology by Best M/G. 1982, W.H. Freeman & Co.
4. Metamorphic Petrology by Turner, F.J., 1981, McGraw Hill.
5. Metamorphism and Plate Tectonics Regimes by Earnst, W.G., 1975, Dowden, Hutchison & Ross, Inc.
6. petrology of the metamorphic Rocks by Mason, R., 1981, George Allen & Unwin/Thomas Murby.
7. Introduction to igneous and Metamorphic Petrology by Winter, J.D., 2001, Prentice Hall.

4. Sedimentary Petrology.

Classification of Sedimentary rocks. Fabric and framework geometry of sedimentary rocks. Classification texture, Composition and diagenesis of limestone, sandstones, conglomerate, Argillaceous rocks and various other types of sedimentary rocks. Provenance of sedimentary rocks. Study of heavy minerals.

Lab. IV: study of Texture, mineral composition and diagenesis of various types of conglomerates sandstones and limestones in hand specimens and thin sections. Heavy mineral separation and analyses.

Books Recommended:

1. Principles of Sedimentology and stratigraphy by Boggs, S., 2001, Prentice Hall.
2. Sedimentary Geology by Prothero, D., Schwab, F., 1996, W.H. Freeman & Co.
3. Sequence stratigraphy by Emery, D. & Myers, K.J., 1996, Blackwell.
4. Sedimentary Petrology, An Interoduction by Tucker, J.E., 1981, Blackwell.
5. Sedimentary Rocks by Pettijohn, F.J., 1975, Harper and Row.
6. Sedimentary Petrology by Tucker, M.E., 1990, Blackwell.

5. Advance Mineralogy

Physical and Chemical Properties of Minerals. Relationship between the structure chemistry and properties of Silicates, carbonates, oxides, sulfides, and phosphate. Mechanisms of mineral nucleation and crystal growth. Importance of Kinetics in mineral formation. Interpretation of mineral analysis: Recalculation of a mineral analysis in terms of fixed number of anions and where appropriate, cation.

Measurement of mineral triple junction angles, description of grain boundaries and their implication for the development of rock textures. Use of computer programs, including spreadsheets, to calculate mineralogical parameter. Triangular and X-Y plots. Related mineralogical information to the assessment and performance of industrial rocks and minerals.

Lab V: Microscopic identification of the common rock forming minerals in thin section, using transmitted and reflected light microscopy. Identification of common ceramic refractory and slag minerals in thin section.

Books Recommended:

1. Mineralogy for students by Battey, M.H., 1981, Longman.
2. Mineralogy by Berry and Masson, 1983, W.H. Freeman & Co.
3. Mineralogy by Perkins, D., 2002, Prentice Hall
4. Minerals in Thin Sections by Perkins, D., 2000, Prentice Hall.
5. Petrography of Igneous and Metamorphic Rocks by Philpotts, A.R., 1989, Prentice Hall.
6. Atlas of Rock-Forming Minerals in Thin Section by Mackenzsie, W.S. Guilfird, C. P., 1980, John Wiley & Sons.
7. Introduction to Rock Forming Minerals by Deer, W.A., Howie, R.A. & Zussaman, J., 1992, Longman.

GROUP-II PALEONTOLOGY AND STRATIGRAPHY

This group comprises the following courses:

1. Advanced Stratigraphy
2. Micropaleontology
3. Invertebrate Paleontology
4. Vertibrate Paleontology
5. Palynology and Paleobotany

1. Advanced Stratigraphy

Remote sensing and lithostratigraphy: establishment of photo stratigraphical succession and facies analysis. Evolutionalry concepts in Biostratigraphy: diachroneity, evolution and biochronology. Tectonic stratigraphy: interpretation of complex deformed terrains. Principles and practices in event stratigraphy, cyclostratigraphy, seismic and sequence stratigraphy. Stratigraphic applications of Isotope geochemistry. Global standard stratigraphy: chronostratigraphy. Interpretation of Stratigraphic record: facies analysis, sea level changes, paleoenvironment and paleoclimates.

Lab. 1: specified Assignments/projects

Books Recommended:

1. International Stratigraphic, Guide: A Guide to Stratigraphic Classification, Terminology and Profedures by Salvador A, 1994, The International Union of Geological Sciences, Trondheim and Geological Society of America, Inc.
2. Remote Sensing Digital Image Analysis, An Introduction by Richards, J.A., 1983, Springer-Verlag.
3. Principles of Stratigraphical Analysis by Blatt, H., Berry, W.B.N. & Brande, S., 1991, Blackwell.
4. The Geological Interpretation of Well Logs by Rider, M.H. 1986, Blackei.
5. Seismic Stratigraphy: Hand Book of Geophysical Exploration Seismic Exploration by Hardage, B.A., 1987, Vol. 9, Geophysical Press Ltd.
6. Sequence Stratigraphy Sea Level-Change, and Significance for Deep Sea by Haq, B.U., 1991, In Macdonald, D.I.M. (Eds.) Sedimentationn Tectonics and Eeastasy, Sea Level Changes at Active Margins. Special Publication of International Association of Sedimentologists.
7. Facies Models: Response to Sea Level Change by Walker, R.G. & James, N.P., (eds.) 1992, Geological Association of Canada.

2. Micropaleontology

General techniques of collection and preparation of material. Morphological, taxonomic, stratigraphical and paleoecological studies of Foraminifera, Ostracoda, Chitinozoa, Organic walled micropalankton, pollen and spores and miscellaneous group. Study of Nanno Fossils.

Lab. II: Sampling and laboratory techniques. Microscopic examination and identification of selected microfossils from stratigraphy of Pakistan. Preparation of thin section of large foraminifera and their identification.

Books Recommended:

1. Aspects of Micropaleontology by Banner, F.T. & Jord, A.R., 1982, Allen and Unwin.
2. Elements of Micropaleontology by Bignot, G., 1985, Graham & Trotman.
3. Stratigraphy of Fossils Foraminifera by Jenkins, D.G. & Murray J.W., 1981, Ellis Horwood.
4. Introduction to Microfossils by Jones, D.J., 1980, Hafner Pub. Co.
5. Introduction to Marine Paleontology by Haq and Boersma, 1980, Elsevier.
6. Plankton Stratigraphy by Bolli, H.M. & Saunders, 1986, Cambridge Press.

3. Invertebrate Paleontology

Organic evolution and fossil record through ages. Detail Classification, evolution and geographical distribution of important invertebrate phyla like (Brachiopoda, Mollusca, Cnidaria Arthropoda (trilobite) and Echinodermata etc.).

Lab. III: Description and identification of invertebrate fossils

Books Recommended:

1. Invertebrate and Evaluation by Clarkson, E.N.K., 1986, Allen & Unwin.
2. Invertebrate Fossils by Moore, R.C. latest Ed., McGraw Hill.
3. Principles of Paleontology by Raup, D.M. & Stanley, S.M., 1985 W.H. Freeman & Co.
4. Palaeontology by Tugler, V.C.T. & Noeld, E.W., 1985, Pergamon Press.
5. Paleobiology of Invertebrate by Tasch, P., 1980, John Wiley & Sons.
6. A Trip through Time: Principles of Historical Geology by Cooper J.D., 1986,

4. Vertebrate Paleontology

Vertebrate and plant life through ages. Study of some major groups of vertebrate fossils. Evolution of some well known selected Fishes, Amphibians, Reptiles, Dinosaurs and Mammals. Introduction to Paleobotany, Siwalik Fauna and Gondwana Flora.

Lab. IV: Description and identification of vertebrate fossils.

Books Recommended:

1. Paleobotany by Stewart, W.N., 1983, Cambridge Press.
2. Vertebrate Paleozoology by Olson, C.V., latest Ed., Wiley & Interscience.
3. Vertebrate Paleontology by Romer, A.S., 1974, University of Chicago Press.
4. Geology of India by Wadia, D.N., latest Ed., Tata McGraw Hill.
5. Dinosaur Encyclopedia by Don Lessem & Donald F. Glut, 1993, Random House.

5. Palynology and Paleobotany

Introduction, Methods of study, techniques of collection and preparation of palynomorphs. Types and functions of spores. Pollen and spores morphology, development of homospores. Suprageneric classification of trilete spores. Distribution of palynomorphs during various geological periods with special reference to Pakistan. Scope and application of palynology in petroleum Industry. Study of Nanofossils. Introduction, aims and object of paleobotany. Taxonomy of fossil and study of various groups of fossil plants. Paleobotany of fossil fuel reserves.

Lab: Specified assignment/Projects.

Recommended Books:

1. Microfossils by Braiser, M.D., 1980, Allen and Unwin
2. Introduction to Marine Paleontology by Haque and Boersman, 1980, Elsevier.
3. Paleobotany by Stewart, W.N., 1983, Cambridge Press.
4. Principles of Paleobotany by William, C.D., Latest Ed, Ronald Press.

GROUP-III: ECONOMIC GEOLOGY

This group comprises the following courses:

1. Ore Deposits
2. Mineral Exploration
3. Coal Geology
4. Mining Geology
5. Mineral Economics.
6. Metallogeny and Plate Tectonics

1. Ore Deposits

Magmatic deposits: The ultramafic-mafic Cr. Ni-PGE deposits, the mafic-ultramafic Fe-Ni-Cu sulphide deposits, the quartz monzonite-granodiorite Cu-Mo sulphide deposits, the anorthosite-gabbro Fe-Ti deposits. Ores associated with carbonatites. Hydrothermal vein deposits. Iron concentration of sedimentary affiliation. Manganese concentration of sedimentary affiliation. Stratiform sulphides deposits. Stratabound ores of sedimentary affiliation. Ores formed by metamorphic processes. Introduction to tectonic setting and mineralization.

Lab. I: Specified assignments/projects

Books Recommended:

1. Ore Deposits Geology by Edwards, R. & Atkinson, K., 1986, Chapman and Hall.
2. An Introduction to Ore Geology by Evans, A.M., 1980, Blackwell.
3. Mineral Deposits and Global Tectonic Settings by Mitchell, A.H.J. & Garson, M.S., 1981, Academic Press.
4. Minerals Deposits in Relation to Plate Tectonics by Sawkins, F.I.J., 1984, Springer-Verlag.
5. Ore Petrology by Stanton, R.L., 1972, McGraw Hill.
6. Metallogeny and Plate Tectonics by Strong, D.F. (ed.), 1976, Geol. Assoc. Canada.

2. Mineral Exploration

Geochemical exploration: principles of geochemical dispersion, choice of media for sampling, field methods and sampling theory, analytical methods and quality control, and data interpretation geochemical and metallogenic provinces, rock, soil, water and stream sediments geochemical survey for mineral exploration. Case studies and exercise will be the part of practical. Extensive use is made of computer-based data analysis.

Geophysical exploration: principal geophysical techniques, including magnetic, electromagnetic, electrical, radiometric, gravity and seismic methods and applied to mineral exploration. Exercise will be the part of practicals.

Lab. II: Specified assignments/projects

Books Recommended:

1. Economic Evaluation in Exploration, by Friedrich, W.W., 1986, Springer-Verlag.
2. Statistics and Data Analysis in Geology, by Davis, J.C., 1986, John Wiley & Sons.
3. Geological Problem Solving with Lotus 123 for Exploration and Mining Geology, by George, S. Koch, G.S Jr., 1990, Pergamon Press.
4. Geochemistry in Mineral Exploration by Rose, A.W., Hawkes, H.E. & Webb, J.S., 1983, Whitstable Litho Ltd.
5. Geochemical Exploration by Joyce, A.S. 1984, Australian Mineral Foundation.
6. Mineral Prospecting Manual by Chaussier, J.B. & Morer, J., 1987, North Oxford Academic.
7. Exploration and Mining Geology by Peters, W.C., 1978, John Wiley & Sons.
8. Techniques in Mineral Exploration by Reedman, J.H., 1979, Applied Science Publishers.
9. Exploration Methods: Course Notes by Claverino, J., Dawney, R. & Stephenson, P., 1994, Australian International Assistance Bureau.
10. Evaluation of Mineral Reserves by Journal, A.G. 2004, Oxford University Press.

3. Coal Geology

Definition, composition, classification and origin of coal. Lithotypes and coal macerals. Chemical and petrographical analysis. Application of Coal petrography., Depositional environments of coal and coal bearing strata, coalification process, types of coal basins and their tectonic setting, concepts of cyclic deposition in coal basin, origin of splits and partings in coal seams. Comparison between modern and ancient coal forming environments, structural problems relevant to exploration & mining. Coal

utilization and resource evaluation. Coal bearing sequences of Pakistan. Methods of coal exploration, geological, geophysical and drilling. Coal mining and its environmental issues.

Lab. III: Petrography of coal and associated rocks. Specified assignments/projects. Preparation of coals pellets, petrographic methods of coal analysis.

Books Recommended:

1. Significance of Coal Resources of Pakistan by Kazmi, A.H. & Raza, H.A., 1990, Geological Survey of Pakistan.
2. Sedimentology of coal and coal bearing sequences by rehmani, R.A., & Flores, R.M. 1984, International Association of Sedimentologists, Blackwell.
3. Coal Geology and Coal Technology by Ward, C.R., 1984, Blackwell.
4. Terrigenous Clastic Depositional Systems, Application to Petroleum, Coal and Uranium Exploration by Galloway, W.E. & Habday, D.K., 1983, Springer-Verlag.
5. Principles and Applications of Coal Petrology SEPM short course No. 8 by Crelling, J.C. & Dutcher, R.R., 1980, Society of Economic Paleontologists and Mineralogists Indian University at Bloomington.
6. Stach's Textbook of Coal Petrology by Stach, E., et al., 1982 Gebruder Borntraeger.
7. International Handbook of Coal Petrology by International Committee for Coal Petrology, 1985, University of Newcastle Upon Tyne.
8. Coal: Typology, Chemistry, Physics & Constitution by Van Krevelen, D.W., 19814, Elsevier.
9. Coal Combustion and Gasification by Smoot, L.D. & Smith P.J., 1985, Plenum Press.

4. Mining Geology

Terms and definitions of mine workings. Openings through adits, shafts, inclines, vertical cross cuts. Choices of mining methods and modes of extraction. Structural controls in mining: bedding, faults, joints folds, fractures and intrusion. Correlation of data spatial relationship of seams. Surface and underground, mapping methods. Calculation of grade ad tonnage of ore. Gases in mines, spontaneous combustion. Rock pressure and support, collapse of working faces, pillars, longwall timbering, benches, safety measures. Waste disposal management, impact of mining on land. Water, air and biological resources. Remedies, long term planning and rehabilitation. Practical work at an operative mine.

Lab. IV: Specified assignments/project

Books Recommended:

1. Mining Geology by Mckinstry, H.B., latest Ed., Prentice Hall.
2. Exploration and mining Geology by peters, W.E., latest Ed., John Wiley & Sons.
3. Techniques in Mineral Exploration by Reedman, J.H., latest Ed., ASP.

5. Mineral Economics

Estimation of ore reserves/ore resources: Factors affecting mine size grade and distribution of ore body, or reseves, prediction and estimation of cost. Expenditure, capital cost, equipment cost, infrastructure cost and mine excavation cost, operation cost, power and fuel charges, labour charges, maintenance of plant and equipment, drilling and blasting charges, haulage, ore, grade control, administration cost, mineral prospecting cost and time exploration cost. Requiremntnts of revenue calculation, quotation of metal prices, estimates of mine dilution, estimates of mill-recovery, estimates of smelter charges, royalties, and levies, depreciation factor, amortization and depletion allowance. Taxable income, income tax, net profit after taxes, cash flow, time value money and net present value. Risk minimization, sensitively analysis and risk management, limiting financial losses, high grade mining priority, forward selling, limited resources project financing and gold loans. Development decisions based on economic evaluation.

Lab. IV: To develop an economic model for a mineral deposit.

Books Recommended:

1. Techniques in Mineral Exploration by Reedman, J.H., latest Ed., ASP.
2. International Mineral Economics by Goecht, W., Zant, II & Eggert, R.C., latest Ed.
3. A Guide to Mineral Resources Development byWoaks, M. & Carman, J.S., latest Ed.

6. Metallogeny and Plate Tectonics

Introduction to ore deposits. Ore forming processes, Plate tectonic, geology and ore deposits. Ore deposits, Models. Metal deposits of oceanic type crust. Intercontinental hotspots and anorogenic magmatism. Deposits, of the early and advanced stage rifting. Deposits of principal arc. Deposits of arc related rifts. Other arc related deposits. Metal Deposits in relation to collisional events. Tectonic related mineralization in Pakistan.

Books recommended;

1. Metal Deposits in Relation to Plate Tectonics by Sawkins, F.J., 1990 Springer-Verlag.
2. Mineral Deposits and Global Tectonic Setting by Mitchell. A.H.G. & Garson, M.S., 1981, Academic Press.
3. Metallogenic Evolution of a Collisional Mountain Belt in Pakistan: A Preliminary analysis by Sillitoe, R. H., 1978, Jour. Geol. Soc. London, Vol. 135, pp. 377-387.
4. Metallogeny and Plate Tectonic by Strong, D.F. (ed.), 1976, Geol., Soc. Canada Special Publication 14.
5. An Introduction to Ore Geology by Anthony Evans, M., 1987, Blackwell.
6. Ore Deposit Geology, by Edward, R. & Atkinsons, K., 1986, Chapman & Hall.
7. The Earth: A Very Short Introduction by Martin Redfern, 2003, Oxford University Press.
8. Continents and Supercontinents by Rogers, J.J.W., 2004, Oxford University Press.
9. Tectonic Boundary Conditions for Climate Reconstructions by Crowley, T.J., 1998, Oxford University Press.
10. Plate Tectonics and Hydrocarbon Accumulation by Dickinson, W.R. & Yarborough, H., 1982, AAPG Education Course Note Series.

GROUP-IV: ENGINEERING GEOLOGY

This group comprises the following courses:

1. Rock Mechanics
2. Soil Mechanics
3. Seismotectonics
4. Engineering Geology

1. Rock Mechanics

Fabric and mechanical nature of rocks. Determination of rock quality for engineering purposes. Stress strain behaviors of different rocks. Rock mass strength. Theories of failure. Types of fracture. Rock deformation in compression. Factors controlling mechanical behaviors of rocks. Excavation methods in rocks. Distribution of stresses around underground excavations. Use of photo elasticity in rock mechanics. Measurement of stresses in Situ. Wave propagation in rocks. Dynamic Models.

Lab. 1: Specified assignments/projects.

Books recommended:

1. Rock Mechanis for underground Mining by Brady, B.H.G. & Brown, E.T., 1985 Allen & Unwin.
2. Engineering Geology by Beavis, F.C., 1985, Balackwell.
3. Structural and Geotechnical Mechanics by Newark, N.M, latest Ed., Prentice Hall.
4. Engineering Geolog and Rock Mechanics by Duncan, N., latest Ed., Leonar Hill.
5. Rock Engineering by Franklin, J.A. & Dusseault, M.B., 1989 McGraw Hill.

2. Soil Mechanics

Introduction and concept of soil mechanics. Soil formation and its classification, survey and sampling with its important engineering properties like density, permeability, shearing strength, bearing capacity, consolidation and settlements.

Lab. II: Index properties of soil determination of soil density, permeability, unconfined shearing and compressive strength of soil and Attenberg's limits.

Books recommended:

1. Problems in engineering soils by Capper, P.L. & Cassie W.E. & Geddes, J.D., latest Ed., John Wiley & Sons.
2. Engineering Geology by Beavis, F.C., 1985, Black Well Scientific Publications.
3. Structural and Geotechnical Mechanics by Newark, N.M. latest Ed., Prentice Hall.
4. Engineering Geology and rock mechanics by Duncan, N., latest Ed., Leonar Hill.

3. Seismotectonics

Introduction to seismology. Seismology and interior of earth, progress of seismology. Application of seismology. Global mosaic of earthquakes, earthquake effects, depth of earthquake, tectonic pattern, types of seismic waves in earthquake shaking. Causes of earthquakes, size of an earthquake, Stimulation of earthquake by water. Seismicity related with different plate boundaries; Convergent plate boundary, divergent plate boundary, transforms plate boundary and intraplate setting.

Seismicity and tectonics; thin skinned tectonics, thick-skinned tectonics and flake tectonics. Seismotectonics of Himalayas, Hindukush, Zagros, Alps and cordillera orogenic belts. Seismotectonics of Basin and Range Province of USA.

Damage observations and earthquake intensity. Determination of focal depth, location of epicenter, earthquake source mechanism and fault plane solution, seismicity and seismic zoning maps, earthquake prediction and modification, seismic site investigation and surveillance, model test in earthquake engineering.

Seismotectonic study for engineering structures, Nuclear Plants, Highways, Dams, Bridges, Buildings, Waste disposal and slope instability.

Lab. III: Specified assignments/projects

Books recommended:

1. Active tectonics. National Academy press Washington, USA., 1986.
2. Engineering Seismology by Agrawal, P.N., 1991. Oxford and IBH publisher company, New Delhi.
3. An introduction to seismological research history and development by Benjamin, Howell, J.K., 1990., Cambridge University Press.
4. Earthquake a primer by Boit, B.A., 1978, W.H. Freeman and company, San Francisco.
5. Geodynamics of Pakistan by Farah, A., and Dejong, K.A., 1979. Geological Survey of Pakistan, Quetta.
6. Zagros-Hindukush-Himalaya, Geodynamic Evolution by Gupta, H.D., and Delancy, F.M., 1981. Geodynamic series vol., 3. American Geophysical Union Washington, D.C., Geological Society of America Boulder Colorado, USA.
7. Tectonics of the Western Himalayas by Malinconico, L.L., and Lillie, R.J., 1989, special paper, 232 Geological Society of America Colorado, USA.
8. Geological Structures and moving plates by Park, R.G., 1988, Chapman and Hall publisher, New York, 337p.
9. Geology of Earthquakes by Roberts S. Yeats, 1997, Oxford University Press.
10. Elementary Seismology by Richter, C.F., 1958, W.H Freeman and company San Francisco and London.
11. Geophysical method in Geology by Sherma, P.V., 1986 Elsevier, New York, Amsterdam and London, 442p.
12. Neotectonics of North America by Slemmons, D.B., Engdahl, E.R., Zoback, D. & Blackwell, D.D., Geological Society of America Colorado USA.
13. Gravity Field Seismicity and Tectonics of the Indian Peninsula and the Himalayas by Verma, R.K., 1985., Allied Publishers.
14. Geodynamics of the Indian Peninsula and the Indian Plate margin by Verma, R.K, 1991, Oxford and IBH publication company, New Delhi.
15. Physical geology exploring the earth by Wincander, R., 2001, A division of Thomson Learning Canada,
16. The evolving continents, Second edition, by Windlay, B.F., 1982, John Wiley and Sons, New York.

4. Engineering Geology

Preliminary and geological a geophysical surveys and the use of aerial photographs. Drilling methods, drilling equipments and application of results obtained by drilling. Well logging, Disturbed and undisturbed samples. Other exploratory methods like tunnels, edits, test pits, etc. Field testing and applications.

Classification of dams, gravity, buttress, arch earth fill and rock fill dams. Forces acting on dams, investigation for dam foundation. Abutments, reservoir and borrow areas. Causes of failures of the dams with examples. Design criteria, influence of topography and geological features on the selection of site and type of dam. Problems associated with dams, seepage control Grouting materials and methods, Sliding and uplift of the dam. Case histories of various dams in Pakistan.

Behaviour of different materials on the slopes. Factors controlling stability of slopes. Failure mechanics in different materials. Analysis for the stability condition and slope protection. Various kinds of buildings and their foundations. Investigation for different types of building. Field exploration and testing. Laboratory investigations. Foundation analysis and evaluation of the design parameters. Various methods of tunnel excavation in different materials. Investigation and purposes, sporting techniques. Investigation for the sub-grade materials. Highway and building aggregate, evaluation of various materials.

Lab. IV: Specified assignments.

Books recommended:

1. Principles of Engineering Geology by Attewell, P.B. & Farmer, I.W., latest Ed., John Willey & Sons; New York.
2. Engineering geology by Beavis, F.C., 1985, Blackwell Scientific Publications, Melbourne.
3. Principles of Engineering Geology by Johnson, R.B. & Degraff, J.V., latest Ed., John Willey & Sons; New York.
4. Fundamentals, of Engineering Geology by Bell, F.A.G., 1983, Butter Worth.
5. Engineering Geology by Goodman, R.E., 1993 John Wiley & Sons.

GROUP-V: PETROLEUM GEOLOGY

This group comprises the following courses:

1. Petroleum Geology
2. Sequence Stratigraphy
3. Petroleum Engineering & Geophysical Methods.
4. Reservoir Geology
5. Clay Mineralogy
6. Organic Geochemistry
7. Petroleum Geology of Pakistan

1. Petroleum Geology

Origin, migration and accumulation of natural hydrocarbons. Reservoir rocks, porespace and fluid transmissibility, reservoir mechanics, conditions, of temperature and pressure. Geological structure of oil and gas fields of Pakistan, review of important world hydrocarbon fields.

Lab. I: Megascopic and microscopic examination of various important sedimentary rocks in relation to sedimentary environments, sedimentary basin analysis and interpretation. Structural and map exercises concerning oil/gas fields. Laboratory tests on hydrocarbons.

Books Recommended:

1. The World of Petroleum by Deshpande, B.G., 1992, Wiley Eastern Limited.
2. Petroleum Engineering, Drilling and Well Completions by Hall, P., Englewood & Cliffs, N.J. Latest Ed., Carl Gatlin.
3. Hydrocarbons from Coal, by Law, B.E., and Rice, D.D., 1993, AAPG Studies in Geology # 38
4. Petroleum Geology by North, F.D., 1985, Allen Unwin.
5. Sedimentary Basins Evolution by Gerhard Einsele, 1991, Facies and Sediment Budget, (Springer-Verlage).
6. Dynamics of oil and gas accumulations by Perrodo, A., 1983 Elf Aquitaine, France.
7. World of Petroleum by Deshpande, B.G., 1996, Wiley Eastern limited, Delhi.
8. Geology of Petroleum by Laverson, A., 1967, Freeman, San Fransisco.
9. Petroleum Geochemistry and Geology by Hunt, J.M., 1995, Freeman, New York.
10. Elements of Petroleum Geology by Selley, R.C., 1998, Academic Press.
11. Well Log Formation Evaluation by Richard H.Merkel, 1986, AAPG Course notes # 14.

2. Sequence Stratigraphy

Introduction and history: Seismic stratigraphy: seismic reflections and seismic facies, Sequence stratigraphy: concept and significance. Sea level changes, their causes and effects. Accommodation, eustatic sea level curve. Hierarchy of sequence stratigraphic elements. Types of sequences and systems tracts. Forced regressions. Sequence hierarchy and composite sequences. Key surfaces, their recognition and significance. Various approaches of sequence stratigraphy Clastic and carbonate sequence stratigraphy e.g. curves of Galloway, Posser, Vail and Haq. Time Stratigraphy, genetic sequence stratigraphy, fluvial sequence stratigraphy, sequence stratigraphy in core and wire line data

sets. Application of sequence stratigraphy in tectonically active basins. Importance of trace fossils in sequence stratigraphy.

Lab.II: Interpretation and seismic reflections. Surface and seismic facies and identification of sequences.

Books Recommended:

1. Silici-clastic sequence stratigraphy in well logs, cores and outcrops by Van Wagoner, J.C., and others, 1990. Am. Assoc. Petrol. Geol. Meth Expl. Ser. No. 7, 55pp.
2. Sea-level changes and integrated approach by Wilgus, B.S. and others., 1988. SEPM.
3. Seismic Stratigraphy: Application to H-carbon exploration by Payton, C.W., 1977, AAPG Mem. 26.
4. Sequence Stratigraphy and Facies Association by Posamentier H.W. & Others, 1993, Blackwell Scientific Publications.
5. Sequence stratigraphy by Emery, D. & Myers, K.J., 1996, Oxford, Blackwell.
6. Seismic Stratigraphy II, An integrated Approach by Orville Roger Berg & Donald G. Woolverton, AAPG Memoir 39 Tulsa, Oklahoma, USA.
7. Reflection Seismology, A tool for energy resource exploration by Kenneth H. Waters, 1981, Wiley and Sons.

3. Petroleum Engineering and Geophysical Methods

Drilling methods, equipment, fluids, their composition and function. Coring and core analysis. Oil well survey and logging. Well production and simulation. Well completion and extraction methods. Evaluation of the petroleum potential of bore-hole sections using techniques of geophysical logs, the direct evidence of drill cuttings, cores and mud logs.

Methods of geophysical prospecting with special emphasis on seismic methods. Evaluation of bore-hole sections for hydrocarbons and groundwater.

Lab. III: Specified assignments/projects

Books Recommended:

1. Introduction to geophysical prospecting by Dobrin, M.D. & Savil, C.H., 1988, McGraw Hill.
2. Geophysical methods by Robbert, E.S., 1989, Prentice Hall.
3. Petroleum Engineering, Drilling and well Completions by Gatlin, C., latest Ed., Prentice – Hall.
4. Drilling of Oil and Gas by Sereda, N.G. & Solvyon, E.M., latest Ed., Wells Mir Pub.
5. Well Log Formation Evaluation by Merkel, R.H., 1986, AAPG course notes # 14.

4. Reservoir Geology

Reservoir rock types: clastics, carbonates, and non-marine reservoirs. Reservoir properties, depositional and diagenetic controls. Fluid properties and their saturation. Hydrocarbon distributing and fluid contracts. Reservoir zonation and thickness mapping reservoir pore spaces configuration, mapping reservoir heterogeneity. Reservoir estimation and calculation of reservoir volumetric, material balance and production decline curve methods. Appraisal and development of reservoir basic concepts.

Introduction to Reservoir Engineering. Rock and fluid properties. Rock description. Diagenesis. Porosity permeability and fluid saturations. Driving mechanism, formation and evaluation. Core analysis. Well logs and well testing. Reservoir types; saturated and under saturated. Gas and gas condensate material balance equation.

Lab. IV: Specified assignments/projects.

Books Recommended:

1. Introduction to petroleum Reservoir Analysis by Koederitz I.F. Heavey., A.H. and Honarpour 1989, Contribution in Petroleum/Geology and Engineering-6 Gulf.
2. Development and Exploration of Oil and Gas Field by Muravyor, R. et., latest Ed., Peace publishers, Moscow.
3. Petroleum Geology by North F.K. 1985. Allen & Unwin London.
4. Applied Subsurface mapping by Tearpock. D.J. & Bischke. R.E. 1991. Prentice Hall Inc.
5. Basics of Reservoir Engineering by Coss, R., 1993, Editions Technip, Paris.
6. Reservoir Characterization by Lake, L.W. & Carrol Jr, H.B., 1986. Academic Press, London.
7. Modern Well Test Analysis (A Computer Aided Approach) by Roland., H.N., 1995 Petroway.
8. Geostatistical Reservoir Modeling by Clayton V. Deutsch. 2002, Oxford University Press.
9. Well Log Formation Evaluation by Richard H. Merkel, 1986, AAPG course notes # 14.

5. Clay Mineralogy

Introduction, structure and classification of clay minerals. Introduction to analytical methods. Origin and diagenesis: clay minerals during diagenesis and low grade metamorphism. Geological significance: depositional environments; clay minerals and sedimentation; Significance of clay minerals in soils. Industrial applications.

Lab. V: Sample preparation. Identification of clay minerals.

Books Recommended:

1. Clay minerals by Grim R.E., 1986, McGraw Hill, New York.
2. X-Ray Identification and crystal structure of clay minerals by Brown G., latest Ed., Min. Soc. London.
3. Crystal Structure of Clay Minerals and their X-Ray identification by Brindley and Brown 1980, Min Soc. London.
4. X-Ray Diffraction and the Identification and Analysis of Clay minerals by Moore & Renolds, 1989.

6. Organic Geochemistry

Composition of biogenic matters. Geochemical conditions, for the accumulation and formation of hydrocarbons. Generation and composition of petroleum hydrocarbons and coal. Geochemical Assessment of source rocks. Geochemical assessment of primary and secondary migration. Application of difference geochemical prospecting and exploration methods. Geochemistry of oil well water.

Lab. VI: Specified assignments/projects

Books Recommended:

1. Geochemistry, by Beaumont, E.A. and Foster, N.H., 1988, AAPG special publication, No. 8. USA.
2. Geochemical model for characterization of Hydrocarbon Gas sources in Marine Sediments by Bernad B et al., latest Ed., Proceeding nine Offsh technical conference, John Wiley and Sons.
3. Marine Geochemistry by Chester, R. 1990, Unwin Hyman, London.

GROUP-VI: APPLIED GEOPHYSICS

This group comprises the following courses:

1. Seismic Methods and Seismic Stratigraphy
2. Earthquake Seismology
3. Geomagnetism, Paleomagnetism
4. Radiometric Methods
5. Electrical Methods and Bore-Hole Geophysics
6. Geophysical Data Processing
7. Gravity and Magnetic Methods

1. Seismic Methods and Seismic Stratigraphy

Physical principles and basic theory. Seismic waves. Types of seismic methods. Velocities of seismic waves in rocks and factors influencing these velocities. Surveying techniques. Seismic energy sources. Instruments. Data acquisition and processing techniques. Interpretation. Applications and case histories,

Fundamentals of Seismic Stratigraphy. Concepts and models of various depositional systems. Seismic reflections in response to strata surfaces and unconformities. Seismic sequence analysis. Integration of seismic data with geology. Seismic fades analysis. Reflection character analysis. Geologic interpretation and evaluation for reservoirs, source rocks and seals for structural and stratigraphic traps.

Lab. I: Specified assignments on data processing, analysis and interpretation.

Books recommended:

1. Seismic Exploration by Al-Sadi, H.N., 1980, Birkhauser Verlag. Basel.
2. Dobrin, M.B. and SAVIT, C, H, 1988, McGraw Hill.
3. Introduction to Geophysical Prospecting by Kearey, P. & Brooks, M., 1991, Osney Mead.
4. Basic Exploration Geophysics by Robinson, E. S. & Coruh, C., 1988, John Wiley and Sons.
5. Geophysical Methods in Geology by Sharma, P.V., 1987, Elsevier Scientific Publishing Company.

6. Applied Geophysics by Teiford, W. M., Geldart, C.P., Sheriff, R.E. & Keys, D.A., 1976, , Cambridge University Press.
7. Seismic Stratigraphic Interpretation and Petroleum Exploration by Brown, Jr, L. F & Fisher W, B, 1985, AAPG,
8. Field Geophysics by Milson, J, 1989, Open University Press.

2. Earthquake Seismology

Mathematical analysis of seismoiological processes on the basis of elastic wave theory. Seismic waves and their analysis in earthquake seismology. Frequency, magnitude, energy of an earthquake and their relationship. Source parameters and their determination. Composite fault plane solutions of earthquakes and their determination. Geographical distribution of important earthquakes. Earthquakes and their implication on the tectonics of the area.

Lab. II: Specified problems on data processing, analysis, fault solutions and interpretation.

Books recommended:

1. The Interior of the Earth its Structure, Constitution and Evaluation by Bott, M.H.P, 1982, Edward Arnold.
2. Introduction to Seismology by Bath, M. 1979, Birkhauser Verlag, Basel.
3. n Introduction to the Theory of Seismology by Sullen, K.E. and Bolt, B.A., 1985, Cambridge University Press,
4. Quantitative Seismology by Aki, K. & Richards, P.G, 1980, W.H. Freeman & Company.
5. Seismic Waves and Sources by Ben-Menaham, A. & Singh, S.S. 1981, Springer-Verlag.

3. Geomagnetism and Paleomagnetism

Fundamentals of geomagnetism. Magnetic properties of rocks. Description of magnetic field of the earth. Paieomagnetic sampling. Measurement of NRM. Magnetic cleaning techniques and field tests of Paieomagnetic stability. Paleointensity analysis. Palaeomagnetism and its applications.

Lab. II: Specified assignments/projects

Books recommended:

1. Palaeomagnetism by Tarling, D.H, 1983, Chapman and Hall.
2. Rock Magnetism by Nagata, T., latest Ed., Maruzen Co., Ltd.
3. Introduction to Geomagnetism by Parkinson, W.D., 1983, Scottish Acad., Press.

4. Radiometric Methods

Physical principles and basic theory. Radioactivity of rocks. Ratioactive dating methods. Field surveys and instruments. Data processing and interpretation. Applications.

Lab. IV. Specified problems on data acquisition, processing and interpretation.

Books recommended:

1. Introduction to Geophysical Prospecting by Dobrin, M.B. and Savit, C. H. 1988, McGrawHill.
2. An Introduction to Geophysical Exploration by Kearey, P, & Brooks, M., 1991, Osney Mead,
3. Basic Exploration Geophysics by Robinson, E. S. & Coruh, C., 1988, John Wiley and Sons,
4. Geophysical Methods in Geology by Shamna, P.V., 1987, Elsevier - Scientific Publishing Company.
5. Field Geophysics by Milson, J., 1989, Open University Press.
6. Radon Mapping in the Search for Uranium by Telford, W.M., 1982, In; Fitch, A.A. (ed.) Developments in Geophysical Exploration Methods. Applied Science.

5. Electrical Methods and Bore-hole Geophysics

Fundamentals of current flow in the earth. Electrode arrangements and field procedures. Instruments, Processing and interpretation of resistivity data. Field procedure, data acquisition and interpretation of self-potential, Induced polarization and electromagnetic methods. Study of Case histories. Principles of well-logging and theory. Formation evaluation. Different types of logging techniques and their fundamentals. Interpretation and applications.

Lab. V. Specified assignments on data acquisition/processing and interpretation.

Books recommended:

1. Introduction to Geophysical Prospecting by Dobrin, M.B. and Savit, C. H., 1988, McGraw Hill.
2. Applied Geophysics by Telford, W. M., Geldart, C.P., Sheriff, R.E. & Keys, D.A., latest Ed., Cambridge University Press.
3. Field Geophysics by Milson, J. 1989, Open University Press.
4. Interpretation Theory in applied Geophysics by Grant, F.S. & West, G.F., latest Ed., McGraw-Hill.
5. Interpretation Theory in Applied Geophysics by Grant, F.S. & West, G.F., latest Ed., McGraw-Hill.
6. Drilling Practices Manual by Moone, P.L., 1986, Pen Well,
7. Basic Well Log Analysis for Geologists by Asquith, G.B., and Gibson, C.R., 1982, Am, Assoc. Petroleum Geologists.
8. The Geological Interpretation of Well Logs by Rider, M.H., 1986, Blackie.
9. Fundamentals of Well Log Interpretation, 1. The Acquisition of Logging Data Serra, O., 1984, Elsevier.
10. Fundamentals of Well Log Interpretation, 2. The Interpretation of Logging Data Serra, O., 1986, Elsevier.

6. Geophysical Data Processing

Programming fundamentals. Analysis of geophysical data: analogue to digital; Sampling theorem; variance, regression and cluster analysis; Polynomial, Trend surface, least square methods. Time series and spectral analysis. Generation of digital filters. Linear and recurrent filters and filter performance. Wave shaping filters. Programming to processing and interpret data.

Lab. VI: Specified assignments/projects

Book recommended:

1. Statistics for Geoscientists: Techniques and applications by Pal, S.K., 1998. Concept Publishing Company.
2. Statistics and Data Analysis in Geology by Davis, J.C., latest Ed., John Wiley.
3. Geomathematics by Agterberg, F.P., latest Ed., Elsevier.
4. Spectral Analysis in Geophysics by Bath, M., latest Ed., Elsevier,
5. Fundamental of Geophysical Data Processing by Claerbout, J.F., latest Ed., McGraw Hill.
6. Introduction to Digital Filtering in Geophysics by Kulhanek, O., latest Ed., Elsevier.

7. Gravity and Magnetic Methods

Physical principles and basic theory. Instrumentation- Planning of the survey and evaluation of errors. Different survey methodologies. Rock densities/rock susceptibilities and their measurements, isostasy. Data acquisition and reduction. Gravity/magnetic anomalies. Interpretation: Regional fields and residual anomalies, Derivatives, continuation of the field, Two and three-dimensional modeling. Application and Case histories.

Lab. VII: Specified problems on data acquisition- Processing and interpretation.

Book recommended:

1. Introduction to Geophysical Prospecting by Dobrin, M.B. & Savit, C. H., 1988, McGraw Hill,
2. An Introduction to geophysical Exploration by Kearey, P. & Brooks, M., 1991, Osney Mead,
3. Basic Exploration Geophysics by Robinson, E.S. & Coruh, C., 1988, John Wiley and Sons.
4. Geophysical methods in geology by Sharma, P.V., 1987, Elsevier Scientific Publishing Company.
5. Applied Geophysics by Telford, W. M., Geldart, C.P., Sheriff, R.E., and Keys, DA, latest Ed., Cambridge University Press,
6. Interpretation Theory in applied Geophysics by Grant, F.S. & West, G.F., latest Ed., McGraw-Hill.
7. Theory of the Earth's Gravity Field by Pick, M., Picha, J. & Vyskocil, V. 1973, Elsevier Sci. Publ. Company.
8. Field Geophysics by Milson, J. 1989, Open University Press.

GROUP VII: GEOCHEMISTRY

This group comprises the following courses:

1. Thermodynamics
2. Geochemical Exploration
3. Isotope Geochemistry
4. High Temperature Geochemistry
5. Low Temperature Geochemistry

1. Thermodynamics

Introduction and definitions of thermodynamic properties such as system, components, entropy, enthalpy, and chemical potential. Laws of thermodynamics, Gibbs's energy and equilibrium G-X and T X diagrams-Henry's Law. Osmosis and osmotic pressure. Ideal and real solutions. Solid solutions. The phase rule with examples of different mineral associations. The ionization of weak electrolytes. Chemical equilibrium of gas and general solution reactions. Calculation of entropy changes in reversible and Irreversible process.

Lab.I: Specified assignments/projects

Books Recommended:

1. Basic Chemical Thermodynamics by Waser., J., latest Ed., the Benjamin Cummings Publishing Company.
2. Equilibrium Thermodynamics in Petrology by Powell. R., latest Ed., Harper & Raw Publishers.
3. Thermodynamics in Geology by Fraser, D.G. latest Ed., D. Riedel Publishing Company.
4. Elementary Applied Thermodynamics by Granet I., latest Ed., John Wiley & Sons, Inco.
5. Elements of Chemical Thermodynamics by Yeregin, E.H., 1986, Mir Publishers.
6. Geochemistry by Brownlow, A.H., 1996, Prentice Hall.

2. Geochemical Exploration

Basic principles for geochemical exploration. Geochemical dispersion, geochemical mobility and association of elements. Classification of mineral deposits. Types of geochemical anomalies in bed-rock, residual and over burden, drainage sediments, and natural wafers. Role of path finder elements in mineral exploration. Decay pattern in stream sediments. Statistical interpretation of geochemical data. Geochemical methods and selection of sediments in mineral exploration with emphasis on litho stream sediments and soil survey. Geochemical evaluation and appraisal of ore deposits.

Lab.II. Preparation of histogram, frequency diagrams and geochemical maps.

Books Recommended:

1. Geochemistry in Mineral Exploration by Rose, A.W. Hawkes, H.E. & Webb, J.S., 1981, Academic Press.
2. Barringer Research, Rexadale.
3. Geochemical exploration by Joyee, A.S. 1984, Australian Mineral Foundation. Incorporated.
4. Geochemical Exploration by Elliott, I.L. & Fletcher, W.K., latest Ed., Elsevier Scientific Publishing Company.
5. Petroleum Geochemistry and Basin Evaluation by Gerard Demaison & Relof J. Mum's, 1984, AAPG Memoir 35.

3. Isotope Geochemistry

Theoretical and experimental principles. General characteristics of isotopes. Isotope fractionation processes, isotope exchange, kinetic effects. Mass spectrometry. Oxygen and Hydrogen isotopes: Introduction, isotope composition of waters from various sources. Oxygen fractionation of rock forming minerals. Oxygen and hydrogen isotopes in igneous sedimentary and metamorphic rocks. Carbon isotopes: Introduction, fractionation mechanism, kinetic fractionation, photosynthesis, primary carbon in igneous rocks, application of isotope study of carbonates and hydrothermal ore deposits. Sulphur isotopes; Introduction, Biogenic fractionation, isotopic fractionation in sulphide minerals and ore fluids. Isotopic evolution of sulphates in marine and non marine sediments.

Criteria for useful radioactive nuclides, Radio active decay mechanisms, The Rb, Sr. Methods of dating: Geochemistry of rubidium and strontium, dating of Rb-bearing minerals in igneous rocks. Dating of igneous, sedimentary and metamorphic rocks. The Carbon 14 method of dating Principles of carbon -14 dating, variation and causes of radiocarbon content of the atmosphere, causes for secular variation, dating of carbonate samples. U-Pb method: Geochemistry of uranium, decay series of uranium. The U-Pb Concordia diagram and alternate models.

Lab.III: Oxygen and Hydrogen Isotope relationship in Hydrothermal mineral deposits. Problems related to hydrothermal mineral deposits. Dating of samples by using $^{235}\text{U}/^{207}\text{Pb}$ method. Dating of samples by using $^{87}\text{Sr}/^{86}\text{Sr}$ ratio.

Books Recommended:

1. Principles of Isotope Geology by Foure, G., 1986, John Wiley & Sons.
2. Stable Isotope Geochemistry by Hoefs, J., 1980, Springer-Verlag.

4. Low Temperature Geochemistry

Factors affecting element distribution in sedimentary rocks. Chemical weathering and rock decomposition. Change in rock composition, Sequence of mineral alteration. Various stages of weathering. Differential loss of elements during weathering Environments/agents of chemical weathering, General nature of weathering reactions such as solution and hydration, weathering of carbonates. Oxidation, hydrolysis of silicates. Transport, formation/deposition and alteration of silica, alumina, and clay minerals. CaCO_3 in surface water. The system CaCO_3 - CaMgCO_3 (sediments and diagenesis). Evaporites and their formation. Oxidation and reduction in sedimentation of iron, manganese and sulphur. Other oxidation and reduction processes. Organic material in sediments such as carbon and its compounds, organic mater In black shales. Carbon compounds as reducing agents. Role of bacteria in the formation of sedimentary ores. Diagenesis of iron minerals.

Lab. IV: Calculation of gains and losses during weathering. Characterization of sedimentary rocks on the basis of their chemistry. The use of geochemical data on sedimentary rocks as a guide to source rock composition, weathering condition and environment of deposition.

Books Recommended:

1. Chemical Fundamental of Geology by Gill, R.C., 1985, Harper Collins.
2. Petrology of Sedimentary Rocks by Greensmith J.T., latest Ed., Gerge Alien & Unwin.
3. Introduction to Geochemistry by Kraskopf, 1982 McGraw Hill.
4. Sedimentary Carbonate Minerals by Lippman, F., latest Ed., Springer-Verlag.
5. Aqueous Environmental Geochemistry, Langmuir, D., 1997 Prentice Hall

5. High Temperature Geochemistry

Geochemical characteristics of igneous rocks as petrogenetic indicator; Binary variation diagrams and fractionation indices. Triangular variation diagrams. Geochemical characteristics of primary magmas. Processes which modify the composition of primary magmas. Convection and mixing in magma chambers, fractional crystallization, crystal contamination, zone refining, liquid immiscibility, gaseous transfer processes. Geochemical characteristics of different magma series.

Distribution of elements in metamorphic rocks. Behaviour of trace elements during the metamorphism of polytic rocks, Geochemical criteria for distinguishing between ortho and para amphibolites and ortho and para gneisses. Geochemistry of granulite facies rocks and problems 'of their origin. Graphical presentation of metamorphic mineral paragenesis (ACF and AKF diagrams). Metasomatism, its types and transfer of material.

Lab. V: Characterization of igneous rocks on the basis of their model and chemical composition. Calculation of normative composition from the major element chemistry of igneous rocks. The use of major and trace element composition of igneous rocks as a means to determine their paleotectonic setting. The use of mineral chemical data for estimating pressure temperature conditions of metamorphism.

Books Recommended

1. Principles of Isotope Geology by Faure, G., 1986, John Wiley & Sons.
2. Geochemistry in mineral exploration by Rose, A.W. Hawkes, H.E. & Webb, J.S., 1981, Academic Press.
3. Igneous petrogenesis by Wilson M. 1989, Unwin Hyman.

4. The interpretation of igneous rocks by Cox K.G. Bell J.D. & Pankhurst, R.J, 1987, George Alien & Unwing.
5. Chemical Fundamentals of Geology by Gill R.C. 1985, Hper Collins.
6. Archean Geochemistry by Kroner, A., Hanson, G.N. & Goodwib., 1984, Springer-Verlog.

GROUP-VIII SEDIMENTOLOGY

This group comprises the following courses:

1. Clastic Sedimentology
2. Carbonate Sedimentology
3. Sedimentary Petrology
4. Basin Analysis
5. Quaternary Geology
6. Clay Mineralogy

1. Clastic sedimentology

Texture of clastic sedimentary rocks. Sedimentary structures, their classification, and hydrodynamic conditions. Pealeocurrent analysis and provenance of clastic rocks. Sedimentary environments and facies. Continental environments: Deserts, rivers lakes, glaciers and wind. Transitional environments; Delta, estuary, interdefaiaic complexes- Marine environments: shelf, slope and deep marine.

Lab.1: Petrographic study of clastic rocks. Heavy mineral analysis. Recording, plotting and analysis of Paleocurrentf data. Field techniques for study of clastic sedimentary rocks.

Books Recommended:

1. Sedimentary Environments and Fades by Reading, H.G. 1986, Blackwell Scientific Publications.
2. Ancient Sedimentary Environments by Selley, R.C., 1978, Chapman & Hall.
3. Origin of Sedimentary Rocks by Blatt. H., Middfeton, G & Murrey, R., latest Ed., Prentice Had.
4. Depositional Sedimentary Environments by Renieck, H.E. & Singh, I.B., 1980, Springer-Verlag.
5. Sand and Sandstones by Pettijohn by F.J., Potter, P.E. & Sever, R., latest Ed., Springer Verlag.
6. Principles of Sedimentoioy by Friedman, G-M. & Sanders, J.E- 1978, John Wiley & Sons.
7. Petrology of Sedimentary Rocks by Boggs Jr. S., 1992, Merril Publishing Co,
8. Sedimentary Rocks by Pettijohn, F.J., latest Ed., Harper & Row.
9. Depositional Systems, A Genetic Approach to Sedimentary Geology by Davis, R.A. Jr. 1983. Prentice-Hall,
10. Sedimentary Petrology, An Introduction by Tucker, M.E., 1981, Black Well Scientific Publications Osney Mead.
11. Terrigenous Clastic Depositional Systems, Application to Petroleum, Coal and Uranium Exploration by Galloway, W. E. & Hobday, D. k., 1983, Springer-Verlag, New York, Inc.
12. A Practical Guide to the Study of Glacial Sediments by David J. Evans, 2004, Oxford University Press.

2 Carbonate Sedimentology

Carbonate mineralogy and chemistry: structure of aragonite, calcite and dolomite, trace elements and isotopes, Dolomite and dolomitization models: Modern and ancient examples. Dolomitization reactions, trace element geochemistry of dolomites, dolomite petrography. Depositional textures and structures: Carbonate constituents, algal stromatolites. Classification of carbonates by Folk and Dunham. Porosity types. Concept of microfacies and microfacies types of Wilson. Major controls on carbonate sedimentation-Depositional processes and facies in carbonate rocks. Carbonate depositional models, platforms, rimmed shelves, ramps, epeiric platforms and isolated platforms. Cyclicity in carbonates. Modern carbonate environments of Bahamas, Florida and Persian gulf. Carbonate depositional systems; Lacustrine, shore line, peritidal reefs, shallow and deep water. Digenetic processes: sequences and models.

Lab. II. Identification of carbonate sediments in hand specimen and then sections. Microfacies interpretations. Staining and XRD techniques.

Books Recommended:

1. Carbonate Sediments and their Diagenesis by Bathurst, R.G, latest Ed, Elsevier.
2. Marine Carbonate by Milliman, J.D, 1974, Springer-Verlag.
3. Carbonate Depositional Environment by Scholle, P.A. Bebout, D.G. & Moore, C.H., AAPG Mem,
4. Carbonate Sedimentology by Tucker, M.E. and Wright, V.P., 1990, Blackwell Scientific Publications
5. Carbonate Depositional Environments by Scholle, P.A., Bebout, D.G. & Moore, C.H., 1993, Mem. Am. Assoc. Petrol. Geol.

3. Sedimentary Petrology

Classification of sedimentary rocks. Fabric and framework geometry of sedimentary rocks. Classification, texture, composition and diagenesis of limestones sandstones, conglomerates, argillaceous rocks and various other types. Provenance of sedimentary rocks. Inclusions, heavy minerals,

Lab. III. Study of texture, mineral composition and diagenesis of various types of conglomerates, sandstones and limestones in hand specimens and thin section. Heavy mineral separation and analysis.

Books Recommended:

1. Sedimentary Rocks by Pettijohn, F.J., latest Ed., Harper & Row.
2. Sand and Sandstones by Pettijohn, F.J. Potter, P.E. & Sever, R., latest Ed., Springer-Verlag,
3. Sedimentary Rocks by Greensmith, J.T., latest Ed., George Allen & Unwin.

4 Basin Analysis

Basin classification Sedimentation and plate tectonics. Basin model concept, Divergent plate margin basins, convergent plate margin basins. Transform margins and pull apart basins. Basins associated with sutures. Cratonic basins. Clastic petrofacies. Factors controlling basin stratigraphy and tectonic mechanism, Eustatic sea level changes; causes and response. Vail and Haq Curves: tectonic vs. eustatic controls. The basin fill depositional style, depositional system and facies models. Continental, coastal, near shore and deep sea depositional systems. Sedimentary basins of Pakistan.

Lab. IV: Stratigraphic columns and their correlation. Textural data interpretation. Paleocurrent data interpretation. Basin mapping methods. Clastic petro facies analysis, interpretation of depositional basins and source area,

Books Recommended:

1. Basin analysis; Principles and Applications by Allen, P.A. and Allen, J.R. 1990 Blackwell Scientific Publications.
2. Foreland Basins by Allen, P.A, and Homewood, P & Wilium, G.D., 1986, Blackwell Scientific Publications-
3. Sedimentary Basin Evolution, Facies and Sediment Budget by Emslie, G., 1992.
4. Sedimentary Environment and Facies by Reading, H.G., 1986, Blackwell Scientific Publications.
5. Geology and Tectonics of Pakistan by Kazmi, A.H. and Jan, Q., 1997, Graphic Publishers.
6. Geology of Pakistan by Bender and Raza, (ed.) 1995, Gebruder Borntraeger.
7. Sedimentary Petrology by Tucker, M.E., 1991, Blackwell Publications.
8. Principles of sedimentary Basin Analysis by Andrew D. Mial, 1990., Springer-Verlag, New York inc.

5. Quaternary Geology

The Quaternary period: character, duration, development and climatic changes Morphological evidence. Landforms. Pleistocene glaciation, and sea level changes. Lithological evidence of environments. Types of sediments. Isotopes in deep-sea sediments. Biological evidence; plant fossils and animal remains. Dating methods; Quaternary stratigraphy and correlation. Neotectonics. Quaternary deposits of Pakistan.

Lab.V. Sampling techniques. Assignments on specified topics.

Books Recommended:

1. Principles of Geomorphology by Thornbury, W.D., 1991, Wiley Eastern Ltd.

2. Geology and Tectonics of Pakistan by Kazmi, A.H. and Jan, Q, 1997, Graphic Publishers
3. Geology of Pakistan by Bender and Raza, (ed.) 1995, Gebruder Borntraeger.

GROUP-IX HYDROGEOLOGY

This group comprises the following courses:

1. Hydrology
2. Groundwater Investigations
3. Groundwater Engineering
4. Hydro chemistry & Groundwater Pollution

I. Hydrology

The role of groundwater in the hydrological cycle. Groundwater occurrence in different aquifer types and climates. Methods of estimating recharge and discharge. Physical and mathematical description of groundwater problems. Flow nets, tube wells, drains and ditches. Consideration of time-variant flow and steady-state flow. Field and laboratory measurements of hydraulic properties of different geological materials. Groundwater modeling techniques and resource management- Soil water balance and water budget estimate of aquifers.

Lab.I: Measurement of hydrogeologic properties of water-bearing formations. Practical applications of mathematical ground water model.

Books Recommended:

1. Groundwater and Wells by Driscoll, F.G., 1989. Johnson Filtration System Inc. St. Paul,
2. Groundwater Hydrology by Todd, D.K., 1980, John Wiley and Sons.
3. Groundwater by Freeze, R-A. & Cherry, J.A., 1979, A. Simo and Schusfer Company.
4. Principles of Hydrology by Ward, R.C. & Robinson, M., 1990, McGraw-Hill Book Company.
5. Physical and Chemical Hydrogeology by Domenico and Schwartz, 1996, John Willey and Sons.
6. Applied Hydrogeology by Fetter, W, 1988, Merril.
7. Introducing Grounds Water by Price, M., 1995, Alien and Unwin.

2 Groundwater Investigation

Groundwater exploration techniques, geological and hydrogeological maps, aerial photographs and satellite imageries. Use of various geophysical methods in groundwater exploration. The application of surface geophysical surveying to groundwater problems including identification of aquifer geometry, aquifer properties and water quality. Principles and application in hydrogeology of well logging techniques.

Lab. II: Field survey and interpretation of available data.

Books Recommended:

1. Field Hydrogeology by Braissington, R., 1998, John Wiley and Sons,
2. Groundwater Resource Evaluation by Walton, W.C., latest Ed., McGraw-Hill Kogakusho, Ltd.
3. Groundwater and Wells by Driscall, F.G., 1989, Johnson Filtration System Inc. St. Paul.

3. Groundwater Engineering

Groundwater problems in site selection and construction of dams and other huge structures. Geotechnical logging and grouting techniques. Groundwater table and its flow into excavations. The principles and applications of dewatering. The effect of groundwater on soil and rock strength. Deep aquifers testing and groundwater flow analysis into underground workings. Hydrogeology of mining areas. The analysis of ground subsidence related to groundwater obstruction.

Lab. III: Case studies related to dame site selection

Books Recommended:

1. Engineering Hydrology by Wilson, E.M., 1991, MacMillan Education Ltd.
2. Field Hydrogeology by Brassington R. 1988, John Wiley and Sons.
3. Groundwater by Freeze, R.A., & Cherry, J.A., 1979, A Simon and Sechuster Company.

4. Hydrochemistry & Groundwater Pollution

Laws of chemistry related to water and its reaction with the aquifer matrix. Principles and processes controlling composition of natural water. Methods of water sampling and analysis. Properties and constituents of water. Presentation, evaluation and interpretation of water analysis data. Sources, nature and effects of groundwater pollution. Transport of pollutants and chemical processes occurring in aquifers, Groundwater contaminations prevention and remedies. Water treatment and techniques for the removal of physical biological and chemical contaminants. Saline intrusions in coastal and estuarine sediments.

Lab. IV: Groundwater sampling for chemical analysis. Graphic presentation of chemical analysis data. Preparation of subsurface hydrochemical maps. Identification of the source and extent of contamination.

Books Recommended:

1. Domestic Water Treatment by Lehr, J.H., Grass, T.E. Pettyjohn. W.A. & Marie, J. De., 1988, National Water Well Association Ohio.
2. Ground Water and Wells by Driscoll, F.G., 1989, Johnson Filtration System Inc. St. Paul.
3. Study and Interpretation of the Chemical Characteristics of Natural Water by Hem, J.D, 1992, US Geological Survey Water.
4. The Global Water Cycle by Berner, F.K., & Bernes, R.A., 1987, Prentice Hall.

GROUP-X: INDUSTRIAL MINERALOGY

This group comprises the following courses:

1. Industrial Mineralogy
2. Geology & Technology of Industrial Minerals and Rocks
3. Instrumental Techniques
4. Mining Geology and Mineral Economics

1 Industrial Mineralogy

Physical and chemical properties of minerals. Relationship between the structure, chemistry and properties of carbonates, sulphates, silica minerals, feldspars, clay minerals, nepheline, serpentine, amphiboles, micas, olivines and phosphates. Mechanisms of mineral nucleation and crystal growth. Importance of kinetics in mineral formation.

Interpretation of mineral analysis Recalculation of a mineral analysis in terms of fixed number of anions, and where appropriate cations. Plotting a phase diagram from experimental data. Interpretation of phase diagrams including the SiO_2 - SiO_2 , Al_2O_3 - SiO_2 - Al_2O_3 - K_2O - SiO_2 , CaO - MgO - SiO_2 , Al_2O_3 - CaO . Drawing of isothermal sections through ternary phase diagram and their relevance. Plotting data on triangular diagrams. Measurement of mineral triple junction angles, description of grain boundaries and their implication for the development of rock textures. Use of a variety of computer programs, including spreadsheets, to calculate mineralogical parameters. Triangular and X-Y plots. Relating mineralogical information to the assessment and performance of industrial rocks and minerals.

Lab. I: Microscopic identification of the common rock forming minerals in thin section, using transmitted and reflected light microscopy. Identification of common ceramic, refractory and slag minerals in thin section.

Book recommended:

1. Mineralogy for Students by Battey, M.H., 1981, Longman.
2. Process Mineralogy of Ceramic Materials by Baumgart, W., Dunham, A.C. & Amstutz, G.C, 1988, Enke, Stuttgart.
3. Crystal structures of clay minerals and their X-ray Identification by Brindley, G.W. & Brown, G., 1980, Mineralogical Society.
4. An Introduction to the Rock-Forming Minerals by Deer, W.A., Howie, R.A. & Zussman, 1992, Longman,
5. A practical introduction to optical mineralogy by Gribble, C.D. & Hall, A.J., 1985, George Allen & Unwin.
6. Applied Mineralogy by Jones, M.P. 1987, Graham and Trotman.

7. X-ray diffraction and the identification and analysis of clay mineral by MOORE, D.M. & Reynolds, Jr., R.C., 1989, Oxford University Press.
8. An introduction to Metamorphic Petrology by Yardley, B.W.D., 1989, Longman.

2. Geology & Technology of Industrial Minerals and Rocks

The geological setting, mineralogy, physical and chemical properties, beneficiation, search methods and uses of the following: Sands and gravels, Hard rock aggregates, dimension stone, slate, limestone and dolomite, magnesite, clays (Common clay/shale, Kaolin, bentonite, and Fullers earth), Silica sand, dunite and serpentinite, feldspars, Nepheline syenite. Natural abrasive raw materials, gypsum, anhydrite, chromite, barite and gemstones including diamond.

Mineralogy and chemistry of raw materials for cement, glass, agriculture, chemical and for refractories. Industrial minerals and their environmental impacts.

Lab. II: Specified assignments/projects

Books recommended:

1. Mineral Deposit Evaluation: a Practical Approach. By Annels, A.E., 1991, Chapman and Hall.
2. Geology of the Industrial Rocks and Minerals by BATES, R-L. 1960. Dover.
3. Mineral Resources and Their Management by Lunden, J.B., 1985, Longman.
4. The Chemistry and Technology of Lime and Limestone by Boynton, R.S, 1980, John Wiley & Sons,
5. Structural Clay Products by Brownell, W.E., 1976. Springer-Verlag.
6. Aggregates: Sand, Gravel and Crushed Rock Aggregates for Construction Purposes by Collis, L. & Fox, R.A. 1985. The Geological Society.
7. Refractories for Iron- and Steelmaking by Chesters, J.H., 1974, The Metals Society.
8. Alkali-silica Reaction in Concrete by Hobbs, D.W., 1988. Thomas Telford Ltd, London.
9. Industrial Geology by Knill, J.L, 1978, Oxford University Press.
10. The Chemistry of Cement and Concrete by Lea, F.M., 1970, Edward Arnold,
11. Industrial Minerals and Rocks by Lefond, S.J., 1983, American Institute of Mining; Metallurgical and Petroleum Engineers.
12. Geology of Construction Materials by Prentice, J.E., 1990, Chapman and Hall.
13. Mineral Processing Technology by Wilts, B.A., 1988, Pergamon Press

3. Instrumental Techniques

Theory of X-ray diffraction for mineral investigation of geological materials. Methods of sample preparation. Software programme. Calibration curve for quantitative analysis and identification of minerals by XRD and JCPDS card files. Theory and practical aspects of DTA (Differential Thermal Analysis). TG (Thermogravimetric) analyzer.

Physical properties: Particle size measurements, sieving, sedimentation, density/SG, automated methods (coulter counter). Surface area measurements. Gas absorption, BET equation, permeability. Colour specifications, atomic absorption spectrophotometric curves. CIE system and their importance to industry.

Lab. III: Liquid and plastic limit of clays. Froth floatation and scrubbing of sands. Separation of clays by hydrocyclone. Viscosity measurement by Bookfield viscometer.

Books Recommended:

1. Atomic Absorption Spectroscopy by Welz, B., 1976, Verlag, Chemie. Weinheim,
2. Differential Thermal Analysis by MacKenzie, R.C., latest Ed, Academic Press-
3. Introduction to Mass Spectrometry and its Applications by Kiser, R.W., latest Ed., Prentice-Hall,
4. Elemental Analysis in Geochemistry by Volborth, A., latest Ed., Elsevier Publishing Company.
5. Introduction to X-ray Spectrometry by Williams, K.L, 1987, George Allen & Unwin.
6. Laboratory Handbook of Petrographic Techniques by Hutchison, C.S., latest Ed., John Willey & Sons.

GROUP-XI: ENVIRONMENTAL GEOLOGY

This group comprises the following courses:

1. Environmental Geology
2. Soil and Water Resources
3. Environmental Hazards
4. Hydrological Systems and Environment
5. Environmental Impact Assessment and Management.

1. Environmental Geology

Introduction to environmental geology. Management of land, water and mineral resources. Environmental controls for erosion: desertification and coastal degradation. Geological hazards and their remedial measures. Environmental impact of mining and geotechnical projects such as dams, reservoirs, highways, their assessment and control. Cleaner sources of energy. Industrial pollution: impact on human health. Environmental parameters of urbanization.

Lab. I: Specified assignments/projects

Books Recommended:

1. Environmental Geology by Keller, E. A., 1979, Merrill.
2. Environmental Geology by Montgomery, C., 1985, J. Wiley.
3. Applied Chemical Groundwater Hydrology by Mazore, E., 1988, McGill.
4. Earthquake Risk & Damage by Liu, B. C., 1981, Westview.
5. The Encyclopedic Dictionary of Environmental change by John A, Mathews, 2003, Oxford University Press.

2. Soil and Water Resources

Soil erosion and land use- Predicting and controlling soil erosion. Soluble salts in soils, aerosol particulate matter, Hydrological System and agriculture. Natural water resources and policy making. Hydrological cycle, Frozen water reserves. Global warming and surface water resources. Surface water storage and ecological system. Ground water movement. Water logging and Salinity.

Lab. II: Specific assignment/projects.

Books recommended:

1. Global Environmental Changes by Moore, P. D. 1996, McGraw Hill.
2. Air Pollution and Engineering Management by Davis, W. T., 2000. John Wiley & Sons.
3. Environmental Chemistry of Soil by Murray B. M., 1994, Oxford University Press-

3. Environmental Hazards

Flood control, information on river flooding. Effects on agro-economy, slope stability in hilly areas, Types of landslides. Their causes and remedial measures. Methods of analysis of slopes. Landslide inventory mapping, Information on landslides and their effects on socio-economic conditions. Study of case histories in Pakistan and abroad. Snow avalanches. Subsidence mechanism and related problems. Earthquake hazards, Hazardous minerals in mining. Safety and health standards, legislations, regulations and controls, effect on global environment.

Lab. III: Specific assignment/projects.

Books recommended:

1. Environmental Geology by Montgomery, C. W., 1986, Wm.C. Brown Publishers.
2. Geology and Hazardous Waste by Hussain, S. E., 1996, Prentice Hall.

4. Hydrological Systems and Environment

Surface and groundwater resources, precipitation, evaporation, erosion and silting in catchment areas and reservoirs (DAMS), Surface and groundwater contamination and sources. Effect of mineralogy, mining activities, Industrial effluents. Heavy metal concentration. Contamination due to chemicals and sewage system, decomposable organic matter and pollutant agents (industrial and Agricultural -

Fertilizers etc.), dissolved gases, minerals and suspended impurities In surface and groundwater, biological contamination (viral, bacteria!, protozoal and helminths).

Lab. IV: Specific assign men t/p rejects.

Books recommended:

1. Groundwater Contamination by Badiant, P., 1999, Printice Hall.
2. Municipal Sewage sludge by Cecil, D., 1992, Technomic Publishing Co.
3. Sources and Fates of Aquatic Pollutants by Ronald A. Hites, 1987, Oxford University Press,

5. Environmental Impact Assessment and Management

Reclamation of agricultural land, landfill and land use, socio-economic uplift, underground drainage system, installation of tube wells and canal lining, vegetation, rock bolting, guniting and shotcreting. Identification of environmental hazards and evaluation of risks, slope and flood control instrumentation - gauges, extensometers and tiltmeters etc. Policy making about water distribution, use of pesticides: insecticides and fertilizers etc. Policy making about water distribution, use of pesticides, insecticides and fertilizers. Disposal of Industrial and Radioactive wastes.

Lab. IV. Specific assignment/projects.

Books recommended:

1. Solid Waste Management by Grever, V., 2000, Oxford & IBH (Ltd.).
2. Environmental Management by Mukharjee, B, 2000, Vikas Publishing Hon.
3. Environmental Assessment by Singleton, R. Castle, P., and Short, D., 1999, PB Kenedy (Donlin Ltd.).
4. Global Change in the Holocene by Anson Mackay, 2005, Oxford University Press.
5. Tectonic Boundary Conditions for Climate Reconstruction by Thomas J. Crowley, 1998, Oxford University Press.

GROUP- XII: STRUCTURE, TECTONICS AND NEOTECTONICS

This group comprises the following courses:

1. Structural Geology
2. Metamorphic Structures
3. Applied Structural Techniques
4. Tectonics of Pakistan
5. Regional Tectonics
6. Neotectonics

I. Structural Geology

Strain analyses: concept of strain ellipse, distortion and rotation, heterogeneous strain, displacement vector fields and strain. Planar and linear fabrics: analyses of fabrics, axial plane foliations/cleavages and their types and origin, transposed foliations, lineation types and Origin. Fabrics as kinematics indicators. Structures in folded rocks: fold morphology and classifications (dimensions, shapes, fourier analyses, wavelength-amplitude analyses, axial trace constructions, symmetry, layer thickness variations, dip isogons), mechanisms of folding, strain and small scale structures in folds, superposed folding. Fault geometry and morphology: classification of fault systems, geometry of a) extension, 2) strike slip and 3) thrust fault systems. Fractures and joints: mechanical analyses of fractures, ductile and brittle shear zones, geometric classification of joints, analyses of Joints in uniformly dipping strata and in folded rocks,

Lab. I: Specific assignment/projects.

Books recommended:

1. Structural Geology by Hatcher, R. D., 1995, Prentice Hall.
2. Structural Geology of Rocks and Regions by Davis, G. H. & Reynolds, S. J., 1996, Wiley
3. Structural Geology by Twiss, R. J. & Moores, E. M., 1992, Freeman.
4. An Outline of Structural Geology by Hobbs, B.E, Means, W, D. & Williams, P, F, 1976, John Willey & Sons.
5. Principals of Structural Geology by Suppe, J., 1985, Prentice Hall.

6. The Techniques of Modern Structural Geology. V.I Stress and Strain by Ramsay J.G. & Huber, M.I., 1983, Academic Press.
7. The Techniques of Modern Structural Geology, V.II Folds & Fractures by Ramsay J.G. & Huber, M.I., 1987, Academic Press.

2. Metamorphic Structures

Microstructures in deformed and metamorphosed rocks. Crystal defects, crystal plasticity, dislocations. Annealing recrystallization, recovery. primary-, secondary recrystallization, dynamic recrystallization, stress induced recrystallization, strain induced recrystallization and associated microstructures, driving forces for dynamic recrystallization, dynamic recrystallization by subgrain rotation and grain boundary migration, controls on migration rates.

Mylonites. Terminology, microstructures, planar and linear ductile fabric and kinematic indicators. Petrofabrics: Factors controlling fabric development, fabric representation-pole and inverse pole figures, orientation distribution functions, measuring techniques, pressure solution and metamorphic differentiation, cataclastic deformation.

Lab. II: Specific assignment/projects.

Books Recommended:

1. Structural Analyses of Metamorphic Tectonites by Turner, F.J & Weiss, L, E, latest Ed., McGraw-Hill.
2. The Study of Fabrics of Geological Bodies by Sander, B., latest Ed., Pergamon Press
3. Metamorphic Textures by Spry, A. H., latest Ed., Pergamon Press.

3. Applied Structural Techniques

Elementary techniques: measurement of attitude and location, contour maps, attitude and dimension calculations, stereographic projections, stereographic poles and rotations, calculation of layer attitudes in drill holes, equal area. Projections and structural analyses. Practical strain measurements of a) initially circular and elliptical markers, b) lines and c) angles, methods and representation of strain state. Progressive displacement and progressive deformation, interpretation of geological maps. Analyses of fracture array geometry. Constructing profiles and block diagrams of folds. Cross Section balancing for thrust and normal fault systems. Depth to detachment calculations

Lab. III: Specific assignment/projects -

Books Recommended:

1. Applied Subsurface Geological Mapping by Tearpook, D. J. & Bischke, R. E., 1991, Prentice Hall.
2. Basic Methods of Structural Geology by Marshak, S. & Mitra, S., 1988, Prentice Hall.
3. The Techniques of Modern Structural Geology by Ramsay, J. G. & Huber, M. I., 1983, Volume I: Strain Analyses, Academic Press,
4. The Techniques of Modern Structural Geology by Ramsay, J. G. and Huber, M. I., 1987; Volume II: Folds and Fractures- Academic Press.
5. Structural Geology, an Introduction to Geometric Techniques by Ragan, D. M, 1985, John Wiley & Sons).
6. Principles of Structural Geology by Suppe, J. 1985, Prentice Hall.

4. Tectonics of Pakistan

Concept of pangea and gondwana supercontinents. Permian separation of Afghan, Pamirs, Karakoram, Lahasa microcontinents, closure of palaeotethys and accretion tectonics at Urasia's southern margin. Early Cretaceous split and northward flight of India, closure of northern Neotethys and collision tectonics of the Shyok Suture. Himalayan orogeny; constraints on the timing of India-Eurasia collision; resultant physiography, structures, metamorphism, climatic changes. Tectonic zonation of Pakistan: Each zone to be studied in terms of its geomorphology, tectonics, stratigraphy, metamorphism, magmatism and mineral deposits. Karakoram plate.

Kohistan-Ladakh island arc terrane. The Himalayas: internal and external zones. Swat, Besham, Hazara, Kaghan (Nanaga Parbat) blocks. The hill ranges (Sammara, Kalachitta, Margala, Galiats), Kohat-Potwar plateaus and the salt ranges. The boundary faults and related tectonics: MMT, MCT, Panjal Thrust, MBT, MFT. Afghan-India collision zone: Kurram-Waziristan-Muslim Bagh-Bela

ophiolite/melange belt, Sulaiiman-Kirthar thrust-fold belt. Katawaz basin, Makran accretionary prism. Raskoh-chagai arc terrane. Indus platform and foredeep. offshore Pakistan: The Indus delta.

Lab. IV: Specific assignment/projects,

Books Recommended:

1. Geology and Tectonics of Pakistan by Kazmi, A. H. and Jan, M. Q., 1997, Graphic Publishers.
2. Geology of Pakistan by Bender and Raza, (ed.) 1995, Gebruder Borntraeger.
3. Geodynamics of Pakistan Farrah, A, and DeJong, K., 1979, Geological Survey of Pakistan.
4. Himaayan Tectonics by Treloar P. J. and Searle, M- P., 1998, Geological Society London, Special Publication.
5. Tectonics of Nanga Parbat and the Western Himalayas by Khan, M. A., Trefaor, P. J., Searle, M, P., and Jan, M. Q. 2000. Geological Society, London, Special Publications. ,

5. Regional Tectonics

Difference between tectonics and structural geology. Interior of earth and terrestrial Planets. Geophysical techniques in tectonics (seismic refraction, gravity anomalies, geomagnetism). Divergent margins and rifting. Transform faults, strike slip faults and fracture zones. Convergent margins. Collisions. anatomy of orogenic belts. Case studies of orogenic belts. The alpine-Himalaya orogenic belt. The Appalachian-Caledonin orogenic system. The north America Cordillera. The Andes.

Lab. IV: Specific assignment/projects.

Books recommended:

1. Tectonics by Moores, E. M. & Twiss, R. J., 1995, Freeman and Co.
2. Global Tectonics by Keary, P. & Vine, F.J. 1996, Blackwell Science.
3. Plate Tectonics: How it Works by Cox, A. & Hort, R. B. 1986, Blackweli Science,
4. The Evolving Continents by Windley, B. F., 1984, Wiley.

6. Neotectonics

Active tectonics and neotectonics: definitions, direct measurements of tectonic movements, direct measurement with geodetic networks. Triangulation of sites with reference to satellites. Global positioning systems, Neotectonic dating methods. Numerical methods (annual, radiogenic, Chemical and biological changes, correlation). Tectonic geomorphology; offset geologicalg-geomorphological features (paleoseismic Indicators, changes in elevations of coast lines, stream offsets, slope retreat, terraces). Neotectonic behavior of faults and folds. Hazards of active tectonics: Earthquakes, landslides and mass movements. Remote sensing, Applications in neotectonics and related hazards.

Recommended Books

1. Tectonics by Moores, E- M. & Twiss, R. J., 1995, Freeman and Co.
2. Tectonic Geomorphology by Burbank, D. & Anderson, R. 2001, Blackwell Science.