DEPARTMENT OF APPLIED GEOLOGY
DIBRUGARH UNIVERSITY

Rationale, Course structure, & Syllabus
MSc Tech. in Applied Geophysics (AGP) Programme
of 3 years' (6 Semesters') duration

(Proposed New Syllabus discussed in the BOS Meeting held on 12th November 2020 and 16th November 2021;
Implemented from the 2021 session)

2021
(NEW CBCS SYLLABUS)

RATIONALE

The department of Applied Geology is located within the triple junction of the Eurasian, Indian and the Burmese plates which is structurally dynamic, rich in natural resources, (Some of these resources are already proven and some are prognosticated) diverse in its demographic content, highly promising for further exploration and utterly vulnerable for unmindful exploitation and plunder. Unless high-quality knowledge is cultivated by the indigenous institutions and the people at a faster pace, programmes of development cannot touch the projected heights. Geophysics forms the backbone of the tools for exploration in the subsurface. Keeping a watchful eye on the fast-changing scenario of the world economy and the importance of the states of NE India in this overall perspective, the presence of earth science in general and Exploration geophysics in particular needs a strong footing and steady growth in the institutes of higher education so that the frontier problems of the earth science-related research works may attract curious and intelligent students and they are encouraged to take up Geophysics as their passion and profession in more numbers.

From its very inception, the Department of Applied Geology, Dibrugarh University had put its effort to groom good geoscientists having expertise in oil, water and mineral resource exploration. This was done for a considerable length of time by offering a three years MTech Course in Applied Geology that was subsequently modified to a two years MSc. Course in Applied Geology. Introducing a post-MSc. two years' MTech. Course in Petroleum Geology in 2003, the department could extend its vision towards the needs to focused studies and research in the field of oil exploration. Interestingly, the effort could draw national attention from the students from Kashmir to Kerala. In extension to the same vision, the department introduced Advanced Post Graduate Diploma in Petroleum Exploration Geophysics (APGDPEG) of one (1) year duration in 2009. The response was good. Subsequently, the department decided to upgrade and broad-base the existing Diploma course to a Two-Year MTech. (Exploration Geophysics) Programme from 2012-13 academic sessions onward with active collaboration from the OIL and the ONGC. A drive was given to modernizing the syllabus in 2018 based on the counselling from Stanford University, USA. However, continuing global recession, drastic fall in the oil price, affected the number of candidates joining the post-MSc. MTech programme. Accordingly, it was decided to offer a three years Master programme MSc Tech (Applied Geophysics) from the August 2020 session at par with other Universities in India.

The basic objective behind offering Applied Geophysics as an MSc. Tech Programme principally to the students having major in Physics at the graduation level is three-fold. First, to generate quality human resources in the 'high skill' segment of workers who are supposed to explore, develop and exploit principal natural resources like oil, water and minerals in a sustainable manner and increasing thereby the practical importance of higher education in nation-building. Secondly, the introduction of more down-to-earth steps so that the academia-industry symbiosis becomes more meaningful as well as useful. Developing the software-based learning skill has been given additional weightage. Initiation of building up a good infrastructure to conduct research in basin analysis of the Assam & Assam Arakan area as a part of the principal thrust area of the department in the field of 'Tectonics and basin Evolution' studies is the third objective. In conformity with these objectives, the first year of the Programme is devoted to introducing the philosophy of scientific exploration in general and exploration geophysics in particular. Earth System Science approach with emphasis on climate change has been included which is supposed to act as a broader perspective. To develop computational skills besides *Numerical Analysis and Computer programming*, a course *Geoscientific data analysis with MATLAB* has been introduced. The second-year is principally devoted to core issues like Seismology and Seismic methods of data acquisition & processing. Besides this, there is in-depth coverage of Gravity and Magnetic Methods. Electrical methods along with Electromagnetic methods are given sufficient weightage. Elective papers include Hydrogeology and groundwater investigations, and Principles of Stratigraphy. Moreover, there is a 'Field Visit' component which is planned as per convenience. The third-year is devoted principally to more specialised issues of exploration applications like seismic data interpretation, well logging and Reservoir Geophysics. Options were given to choose from the latest fields of concern like *Decision Analysis and Value of Information* and *Simulation modelling in environmental science* etc. Besides the regular fieldwork, serious project works of six months' duration having strictly monitored periodic submission of progress reports related to exploration under the joint supervision of the Department of Applied Geology, Dibrugarh University and reputed organizations (OIL, ONGCL, CSIR- NEIST etc.) are conducted in the final sixth semester to promote research aptitude of the candidates.

PROGRAMME STRUCTURE- MSc.Tech (Applied Geophysics)-Proposed
SEMESTER-I

Course No.	Course	L	P	Cr	Marks		
					IS	ES	Total
Core Courses							
AGP-101	Philosophy of Science & Exploration	3	-	3	40	60	100
AGP-102	Earth System Science	3	-	3	40	60	100
AGP-103	Applied Mathematics for Geophysics	3	-	3	40	60	100
AGP-104	Geoscientific Data Analysis with Matlab	3	-	3	40	60	100
Practical							
AGP-104-P	Geoscientific Data Analysis with Matlab	1		1	20	30	50
Discipline Specific Elective Courses (DSE)							
AGP-1D-1	Physics Essential	4	-	4	40	60	100
AGP-1D-2	Geology Essential	4	-	4	40	60	100
Generic Elective Courses (GE) [offered by the Applied Geology Department]							
AGP-1G-1							
Generic Elective Courses (GE) [offered by other departments]							
Ability Enhancement Courses (AEC) [offered by the department]							
AGP-1A-1	Technical English & Professional Communication	2		2	20	30	50

Total Marks for Semester-I: 600

Total Credits: **19(Minimum)**

SEMESTER - II

Course No.	Course	L	P	Cr	Marks		
					IS	ES	Total
Core Courses							
AGP-201	Geophysical Inversion	3	-	3	40	60	100
AGP-202	Geophysical Prospecting	3	-	3	40	60	100
AGP-203	Geophysical signal theory	3	-	3	40	60	100
AGP-204	Numerical Analysis and Computer programming	3	-	3	40	60	100
Practical							
AGP-204-P	Numerical Analysis and Computer programming	1	-	1	20	30	50
Discipline Specific Elective Courses (DSE)							
AGP-2D-1	Hydrogeology & Ground water investigations	3	1	4	40	60	100
AGP-2D-2	Principles of Stratigraphy	4	-	4	40	60	100
Generic Elective Courses (GE) [offered by other departments]							
Ability Enhancement Courses (AEC) [offered by the department]							
Ability Enhancement Courses (AEC) [offered by other departments]							
AGP-2A-1	Summer Training-I: Field/Industrial visit		2	2	20	30	50

Total Marks for Semester-II: 600

Total Credits: **19(Minimum)**

SEMESTER: III

Course No.	Course	L	P	Cr	Marks		
					IS	ES	Total
Core Courses							
AGP-301	Seismology	3		3	40	60	100
AGP-302	Geophysical Tools I: Seismic Methods (Data Acquisition & Processing)	3		3	40	60	100
AGP-303	Geophysical Tools II: Electrical & Electro Magnetic Methods	3		3	40	60	100
AGP-304	Image Processing & Geographic Information System	3		3	40	60	100
Practical							
AGP-301-P	Seismology	-	1	1	20	30	50
AGP-302-P	Geophysical Tools I: Seismic Methods (Data Acquisition & Processing)	-	1	1	20	30	50
AGP-303-P	Geophysical Tools II: Electrical & Electro Magnetic Methods	_	1	1	20	30	50
AGP-304-P	Image Processing & Geographic Information System	_	1	1	20	30	50
Discipline Specific Elective Courses (DSE)							
AGP-3D-1	Decision Analysis and Value of Information	4		4	40	60	100
AGP-3D-2	Fluvial Dynamics and Tectonic Geomorphology	4	-	4	40	60	100
Generic Elective Courses (GE) [offered by the Applied Geology Department]							
AGP-3G-1	Water Science, Policy & Governance	4	-	4	40	60	100
Generic Elective Courses (GE) [offered by other departments]							
PT-3G-4	Petroleum Reservoir Engineering	2	2	4	40	60	100
PT- 3G-5	Basic Drilling Technology	3	1	4	40	60	100
Ability Enhancement Courses (AEC) [offered by other departments]							
AGP-3A-1	Winter Training-Lab visit		2	2	20	30	50

Total Marks for Semester-III: 750

Total Credits: **22(Minimum)**

SEMESTER- IV

Course No.	Course	L	P	Cr	Marks		
					IS	ES	Total
Core Courses							
AGP-401	Geophysical Tools III: MT & GPR Methods	3		3	40	60	100
AGP-402	Geophysical Tools IV: Gravity & Magnetic Methods	3		3	40	60	100
AGP-403	Geophysical Tools V: Well Logging	3		3	40	60	100
AGP-404	Reservoir Geophysics	3		3	40	60	100
Practical							
AGP-401-P	Geophysical Tools III: MT & GPR Methods		1	1	20	30	50
AGP-402-P	Geophysical Tools IV: Gravity & Magnetic Methods		1	1	20	30	50
AGP-403-P	Geophysical Tools V: Well Logging		1	1	20	30	50
AGP-404-P	Reservoir Geophysics		1	1	20	30	50
Discipline Specific Elective Courses (DSE)							
AGP-4D-1	Marine Geophysics	4		4	40	60	100
AGP-4D-2	Geothermics and Geodynamics	4	-	4	40	60	100
Generic Elective Courses (GE) [offered by the Applied Geology Department]							
AGP-4G-1	Environmental Geophysics	4	-	4	40	60	100
Generic Elective Courses (GE) [offered by other departments]							
Ability Enhancement Courses (AEC) [offered by the department]							
Ability Enhancement Courses (AEC) [offered by other departments]							
AGP-4A-1	Summer Training-II- Field/Industrial visit		2	2	20	30	50

Total Marks for Semester-IV: 750

Total Credits: **22(Minimum)**

SEMESTER- V

Course No.	Course	L	P	Cr	Marks		
					IS	ES	Total
Core Courses							
AGP-501	Seismic Data Interpretation and Basin Analysis	3	1	4	40	60	100
AGP-502	Formation Evaluation	3	1	4	40	60	100
AGP-503	Sequence Stratigraphy	3	1	4	40	60	100
AGP-504	Simulation modeling in environmental science	3	1	4	40	60	100
Practical							
AGP-501-P	Seismic Data Interpretation and Basin Analysis		1	1	20	30	50
AGP-502-P	Formation Evaluation		1	1	20	30	50
AGP-503-P	Sequence Stratigraphy		1	1	20	30	50
AGP-504-P	Simulation modeling in environmental science		1	1	20	30	50
Discipline Specific Elective Courses (DSE)							
AGP-5D-1	Advanced Seismology	4		4	40	60	100
AGP-5D-2	Machine Learning and Artificial Intelligence (MLAI)for Geophysical Applications	4	-	4	40	60	100
Generic Elective Courses (GE) [offered by the Applied Geology Department]							
Generic Elective Courses (GE) [offered by other departments]							
Ability Enhancement Courses (AEC) [offered by the department]							
AGP-5A-1	Research Methodology & Science Writing	2	-	2	20	30	50
Ability Enhancement Courses (AEC) [offered by other departments]							
AGP-5A-2	Industrial Management	2	-	2	20	30	50

Total Marks for Semester-V: 750

Total Credits: **22(Minimum)**

SEMESTER- VI

Course No.	Course	L P Cr	Marks		
			IS	ES	Total
Core Courses					
AGP-601	Dissertation/Project Work	12			500
AGP-602	Seminar	4			100
AGP-603	Grand Comprehensive Test	4			100
AGP-604	Comprehensive Viva Voce	2			50

Total Marks for Semester-VI: 750
Total Credits: **22**

Cumulative Total Marks (I+II+III+IV+V+VI semesters)
=600+600+750+750+750+750=4200
Cumulative Total Credits (I+II+III+IV+V+VI semesters)
=**19+19+22+22+22+22=126 (Minimum)**

Semester	Courses with Credits					
	Core (Fixed)		Elective (minimum one)		AEC (minimum)	Total (Minimum)
	Theory	Practical	DSE	GE		
I	4 Courses × 3 Credits=12	1 Course ×1 Credit =1	1 Course × 4 Credit =4	1 Course × 4 Credit =4	1 Course × 2 Credit =2	19
II	4 Courses × 3 Credits=12	1 Course ×1 Credit =1	1 Course × 4 Credit =4		1 Course × 2 Credit =2	19
III	4 Courses × 3 Credits=12	4 Courses ×1 Credit = 4	1 Course × 4 Credit =4	1 Course × 4 Credit =4	1 Course × 2 Credit =2	22
IV	4 Courses × 3 Credits=12	4 Courses ×1 Credit = 4	1 Course × 4 Credit =4	1 Course × 4 Credit =4	1 Course × 2 Credit =2	22
V	4 Courses × 3 Credits=12	4 Courses ×1 Credit = 4	1 Course × 4 Credit =4		1 Course × 2 Credit =2	22
VI	Dissertation/Project work (12)	Seminar (4)	Grand Composite Test (4)		Composite Viva Voce (2)	22

Note:
Core: Core Courses (Compulsory) / Credits: 3 (Only Theory) / Credits: 4 (Theory + Practical)
DSE: Discipline Specific Elective (Intra-Departmental / Credit: 4)
GE: Generic Elective (Inter-Departmental / Inter-Disciplinary / Credits: 4)
AEC: Ability Enhancement Courses (Inter-Disciplinary / Credits: 2)
L: Numbers of weekly lectures (Each of 1 hr duration and 1 Credit)
P: Numbers of weekly practical (Each of 2hrs duration and 1 Credit)
IS: In-semester marks/ ES: End-semester Marks/ TM: Total Marks

PROPOSED SYLLABUS FOR MSC.TECH IN APPLIED GEOPHYSICS PROGRAMME UNDER CHOICE BASED CREDIT SYSTEM DURING THE ACADEMIC SESSION 2020-2023

Semester I

AGP-101: Philosophy of Science & Exploration

L	Cr	IS	ES	TM
3	3	40	60	100

Unit 1: *Rationale for studying philosophy of science* ***(6 hours)***
The concerns of science, how science differs from theology, philosophy and humanities? The objectives of scientific research; Facts, theories, laws and concepts, experiments and the nature of theories, what is meant by the *state* of a physical system? What constitutes a *field*? What exactly is meant by the *arrow of time*? Scientific and philosophical approaches to knowledge development and knowledge application.

Unit 2: *Philosophy of exploration in science* ***(4 hours)***
The problem of the 'Empirical basis'; Scientific objectivity and subjective conviction; Causality; Explanation and the deduction of predictions; Theoretical systems; Inductive logic and probability logic; Verification and falsification; Discovery and justification; The Path of science

Unit 3: *Structural development of Science and Scientific Thinking* ***(6 hours)***
Essential elements of unity and diversity between Eastern and Western thought pattern and the development of a scientific way of thinking; Ideas of Plato, Aristotle, Francis Bacon, Rene Descartes, David Hume, Karl Popper, Thomas Kuhn, Lakatos, Feyerabend, J D Bernal, Bruno Latour; Scientific ideas of Eastern philosophers

Unit 4: *Convergence of Science and Philosophy* ***(6 hours)***
Existential issues and broad involvement of science; The Newtonian world; Unified Theory, Space-Time Relationship; Relativity, Uncertainty principle; wave-particle duality; quantum theory; Darwin's theory of evolution; Plate Tectonics; Epistemic and ontological aspects.

Unit 5: *Philosophy of application of Geophysical Tools* ***(8 hours)***
A brief history of the development of geophysical exploration; General assumptions involved in the geophysical prospecting; Passive and Active tools, Invasive and non-invasive techniques; Significance of 1-D, 2-D and 3-D problems; reservoir studies involving space-time variability; Application of geophysical methods in oil, mineral and groundwater exploration; Geophysical exploration and nation-building.

Activities**:** Quick reading of selective passages and answering questions, writing essays on contributions of thinkers and philosophers contributing to the development of scientific thinking

References:

1) Popper, K.R., 1959. The logic of scientific discovery, Hutchinson, London.
2) Kuhn, Thomas S., 1962. The Structure of Scientific Revolutions, The University of Chicago Press.
3) Cahn, Steven M. (Edited by), 2000. Exploring philosophy: an introductory anthology, Oxford University Press.
4) Silver, Brian L.,1998. The ascent of science, Oxford University Press.
5) Dobrin, M.B., Savit, C.H., 1988. Introduction to Geophysical Prospecting, 4th Ed. McGraw Hill.
6) Telford, M., Geldart, L.P., and Sheriff R.E., 1990 Applied Geophysics, 2nd Edition, Cambridge University Press.
7) Lowrie, W., 2007. Fundamentals of Geophysics, 2nd edition, Cambridge University Press.
8) Lowrie, W., 2011. A Student's Guide to Geophysical Equations, Cambridge University Press.
9) Barnes, John W., 2004. Basic Geological Mapping, 4th Edition, John Wiley & Sons, Ltd.

AGP-102: Earth System Science

L	Cr	IS	ES	TM
3	3	40	60	100

Unit 1: *Framework of Earth System Science.* ***(4 hours)***
A brief introduction to different spheres; primary causal mechanisms located in individual spheres and their influence on different spheres, Climate forcing, Climate system responses, Feedback in the climate system, Climate archives, Data, and models.

Unit 2: *Scales of climate change.* ***(8 hours)***
Gaia hypothesis; Greenhouse earth, Icehouse earth, BLAG hypothesis, Monsoon circulation, Insolation control of ice sheets, Milankovitch Theory, Orbital scale changes in Carbon dioxide and Methane, The Last Glacial Maximum, Millenial oscillations in climate. Climatic changes during the last 1000 years; Pre and post-industrial revolution climatic changes; Anthropogenic factors contributing to global warming; Future climatic change.

Unit 3: *Geologic Systems* ***(6hours)***
Closed systems; Open systems; Direction of change in Geologic Systems; The hydrologic system; Major subsystems of the hydrologic system like atmosphere-ocean system, river systems, glacial systems, groundwater systems, shoreline systems and Eolian systems; Tectonic systems

Unit 4: *Global Tectonics* ***(6 hours)***
The framework of plate tectonics, Plates and plate margins, Distribution of earthquakes, Direct measurement of relative plate motions, Triple junctions, measurement of relative plate motion, Plate tectonics and economic geology -Autochthonous and allochthonous deposits, Deposits of sedimentary basins, Deposits related to climates.

Unit 5: *Basin Evolution* ***(6 hours)***
An introduction to basin-forming tectonics, depositional sequences and basin-modifying tectonics, types of basin classification, an overview of Indian sedimentary basins, Evolution of Assam Arakan Basin

References:

1. Ruddiman, W.F., Earth's Climate: Past and Future, Freeman and Company, 2013.
2. Allen, P.A., Allen, J.R., 2005. Basin Analysis, Principles and Applications, 2nd edition, Blackwell Publishing
3. Hamblin, W. Kenneth., Christiansen, Eric H., Earth's Dynamic Systems, Tenth edition
   Source: http://www.prenhall.com/hamblin
4. Edited by Jacobson, Michael C., Charlson, Robert J., Rodhe Henning., Orians, Gordon H., 2006. Earth System Science – From Biogeochemical Cycles to Global Change. International Geophysics Series VOLUME 72, Elsevier.

AGP-103: Applied Mathematics for Geophysics

L	Cr	IS	ES	TM
3	3	40	60	100

Unit 1: *An Introduction to Applied Mathematics* ***(6 hours)***
Summaries of basic concepts like Determinants, Vector analysis, Matrix analysis, Complex numbers, Method of least squares, Finite differences and Partial fractions. Linear systems, Digital systems

Unit 2: *Analysis of Complex Variables* ***(6 hours)***
Limit. Continuity and differentiability of a function of complex variables; Analytic functions; Cauchy-Riemann's and Cauchy's in tergal theorem; Moreira's theorem; Cauchy's integral formula; Expansion of function of complex variables in Taylor's and Laurent's series; singularities and poles; Residue theorem; Contour integration; Conformal mappings and its application; Bilinear transformation

Unit 3: *Fourier Analysis* ***(6 hours)***
Fourier series and Fourier coefficients; simple examples; use of exponential representation for harmonic oscillations; expression for Fourier coefficients; Non-periodic disturbance; representation by Fourier integral, Fourier Transform

Unit 4: *Special Functions* ***(6 hours)***
Solution of Bessel and Legendre equations; Recurrence relations and generating function for $J_n(X)$. Elliptic integrals and Error function and their properties
Laplace Transform of simple functions, first and second shifting theorems, t-multiplication and t-division theorems; Laplace transforms of derivatives, integrals and periodic functions.
Inverse Laplace transform and convolution property; Use of Laplace transform in evaluating complicated and improper integrals and solutions of ordinary differential equations related to engineering problems

Unit 5: *Partial Differential Equations* ***(6 hours)***
Classification of partial differential equations, solutions of one-dimensional wave equation; one-dimensional unsteady heat flow equation and two-dimensional steady heat flow equation in Cartesian and polar coordinates by variable separable method concerning Fourier trigonometric series and by Laplace transform technique

AGP-104: Geoscientific Data Analysis with Matlab

L	Pr	Cr	IS	ES	T
3	1	4	40	60	100

Unit 1: *Introduction to Matlab* ***(8 hours)***
Common functions and operations; Arrays: vectors and matrices; Array indexing: subscript indexing, linear indexing and logical indexing; Visualizing data: line plots, scatter plots, polar plots, rose plots, compass plots, contour plots, surface plots, histograms and images; Matrix operations and manipulations; Vectorization; Scripts and Functions.

Unit 2: *Image processing using Matlab* ***(6 hours)***
Transforms: Fourier transform, discrete cosine transform, radon transform, wavelet transform; Filters: Gaussian filter, Laplacian filter, moving average filter, median filter; Frequency responses; Speckle noise removal; Image reconstruction; Edge detection; Image thresholding; Properties of image regions.

Unit 3: *Signal processing using Matlab* ***(6 hours)***
Fast Fourier transform; Sampling and aliasing; Spectral analysis; Power spectral density; Cross-correlation and autocorrelation; Time-frequency spectrogram; High-pass and low-pass filters; Downsampling and removing trends in data; Principal component analysis.

Unit 4: *Simulation* ***(3 hours)***
2D random walk; Monte Carlo simulation; Bootstrapping; Kernel density estimate; Probability density functions; Empirical cumulative distribution.

Unit 5: *Regression, classification and optimization* ***(7 hours)***
Linear least-squares regression; Eigenvectors and eigenvalues; Polynomial fitting; Non-linear least squares regression; Classification: Logistic regression, Classification trees, Neural networks, Support vector machines; Optimization; Objective functions; Numerical solution of ODEs; Numerical integration and discretization.

References:

1) Menke, W. and Menke, J. (2016). *Environmental Data Analysis with Matlab*. Academic Press.
2) Hanselman, D. and Littlefield, B. (2011). *Mastering Matlab*. Prentice-Hall.
3) Moler, C. (2004). *Numerical Computing with Matlab*. SIAM.
4) Van Loan, C.F. and Fan, K.Y.D. (2010). *Insight Through Computing: A Matlab Introduction to Computational Science & Engineering*. SIAM.
5) Middleton, G.V. (2000). *Data Analysis in the Earth Sciences using Matlab*. Prentice-Hall.
6) Johnson, R.K. (2011). *The Elements of Matlab Style*. Cambridge University Press.
7) Online resources at http://www.mathworks.com.

AGP-104-P: Practical: Geoscientific Data Analysis with Matlab

L	Cr	IS	ES	T
2	1	20	30	50

1. Matrix manipulations and matrix indexing, various types of plots, simple data statistics, data gridding and interpolation.
2. Writing m-files.
3. Image processing: 2D discrete cosine transform, Gaussian filter and Laplacian filter, edge detection, median filter, tomography.
4. Signal processing: sampling and aliasing, spectral analysis, cross-correlation and auto-correlation, Fourier transform, time-frequency spectrogram, low-pass filter.
5. Randomized affine transformations, linear equations, linear least squares regression, polynomial fitting.
6. Non-linear least squares regression, numerical solution of ODEs, symbolic toolbox, numerical integration and discretization.
7. Simulation, bootstrap.
8. Multivariate data analysis using cell arrays and structure arrays

AGP-1D-1: Physics Essential

L	Cr	IS	ES	TM
4	4	40	60	100

Unit 1: *Introduction* ***(4 hours)***
Field concept, The coordinate systems, Scalar and Vector fields, Differential elements of length, surface and volume, Line, surface and volume integrals, The gradient of a scalar function, Divergence of a vector field, The Laplacian operator, Some fundamental theorems and field classifications, Vector identities

Unit 2: *Static fields* ***(8 hours)***
Laws and concepts associated with electrostatic (Coulomb's law, Electric field intensity, Electric flux and electric flux density, The electrical potential, Electric dipole, materials in an electric field, Energy stored in an electric field, Boundary conditions, Capacitors and capacitance, Poisson's and Laplace's equations, Method of images), Laws and concepts associated with magnetostatics (Biot-Savart law, Ampere's force law, Magnetic torque, Magnetic flux and Gauss's law for magnetic fields, Magnetic vector potential, magnetic field intensity and Ampere's circuital law, Boundary conditions for magnetic fields, Magnetic circuits)

Unit 3: *Steady electric currents and time-varying electromagnetic fields* ***(8 hours)***
Nature of current and current density, the equation of continuity, Boundary conditions for current density, the electromotive force, Faraday's law of induction, self-inductance, mutual inductance, the inductance of coupled coils, energy in a magnetic field, Maxwell's equations and boundary conditions, time-harmonic fields, applications of electromagnetic fields

Unit 4: *Plane wave propagation* ***(5 hours)***
General wave equations, Plane wavePlane-wave in a dielectric medium, plane wave in free space, plane wave in a conducting medium, plane wave in a good conductor, plane wave in a good dielectric, polarization of a wave, the normal incidence of uniform plane waves, oblique incidence on a plane boundary

Unit 5: *Interaction of fields and matter* ***(5 hours)***
Plasma Oscillations, Wave Propagation in Plasma, Polarization of Dielectric Materials,
Equivalent Volume and Surface Charges, The Permittivity Concept, Magnetic Polarization, Equivalent Volume and Surface Currents, The permeability Concept, Frequency Responses of Dielectric Materials

References:

1) Guru, Bhag and Hüseyin Hiziroğlu, Electromagnetic Field Theory Fundamentals, 2nd Edition, Cambridge University Press, 2004.
2) Jordan, Edward C., Balmain, Keith G. Electromagnetic waves & Radiating Systems, 2nd Edition, Prentice Hall of India Pvt. Ltd, New Delhi, 1990.
3) Roy, K.K., Potential Theory in Applied Geophysics, Springer, 2008.

AGP-1D-2: Geology Essential

L	Cr	IS	ES	TM
4	4	40	60	100

Unit 1: *Earth Materials: Mineralogy, Rocks and the Rock Cycle* ***(4 hours)***
Mineral definition, types and examples, Rocks and the rock cycle, Vulcanicity and igneous rocks, Sedimentary rocks, fossils and sedimentary structures, Metamorphic rocks.

Unit 2: *Earth Surface Processes* ***(5 hours)***
Overview of the Earth, Production of sediment at the Earth's surface, Fundamentals of fluid flow, sediment transport, erosion and deposition, Environments of erosion and deposition, Diagenesis, Long-term large-scale processes: mountains and sedimentary basins.

Unit 3: *Mesoscopic structures and methods of their analysis* ***(8 hours)***
Description of folds, shear zones, faults and fault zones, foliations, lineations, & Veins. Characteristics, style, age analysis and interpretation of Joints. Fault and lineament –array analysis. Fold styles and section lines, construction of profiles for plunging and non-plunging folds.

Unit 4:*Quantitative surface and subsurface map interpretation* ***(8 hours)***
Structure contour maps from profiles fold trend and recognition of cylindrical and conical folds on a tangent diagram, faults- calculations of heave and throw from stratigraphic separation, basic concepts of 3-D structural interpretation, fault cut-off maps & Allan diagrams.

Unit 5: *Sedimentary Basins* ***(5 hours)***
Types of Sedimentary basins, Depositional Systems and facies Models, Subsidence, Denudation and Sediment Budget, An introduction to 'Petroleum Geology'- Kerogen types, Petroleum source, migration, accumulation etc.

Reference:

1. Ruddiman, W.F., Earth's Climate: Past and Future, Freeman and Company, 2013.
2. Haakon Fossen, 2010. Structural Geology, Cambridge university press.
3. Blyth, F.G.H., Fritas, M.H. de, 1984. A Geology for Engineers, Elsevier.

AGP-1A-1: Technical English & Professional Communication

L	GD	Cr	IS	ES	T
2	1	2	20	30	50

Unit 1: *An introduction to scientific communication* ***(8 hours)***

How is scientific communication different from providing information or education? Difference between expressing and communicating; Distinction between target group and readers/ listeners/ viewers; Communicating for impact on target group and to engage media consumers;
Communicating to elicit community action: Dictyostelium model for understanding essential principles; Nature of political, religious and commercial communication;
Communicating science to elicit action, change or reform.
***Activities*:** Writing CV, writing proposal for conducting scientific research

Unit 2: *Language and Science* ***(6 hours)***
Nature of scientific language: Removal of first-person, removal of identities, names of scientists; Use of passive voice; Lack of attention to spelling and grammar in teaching and learning science; Essentials of punctuation; Parts of speech; Tense; Transitions between hypothesis, experiments and results; Connecting words, sentences and paragraphs; Converting complex nouns into simple verbs.
Activities: Learning grammar using web tools, Vocabulary increasing exercises, Phrasal verbs.

Unit 3: *Scientific Communication* ***(3 hours)***
Understanding the structure of a scientific paper;
Searching for and researching scientific content: Google, Google Scholar, Academia.edu, Research gate, Databases, Directories
Reading, writing, rewriting, restructuring
Art of preparing impressive Power PointPowerPoint Presentations
Activities: Asking questions, formulating keywords, searching, bookmarking, using a web-clipper, organizing PDF files, bibliography management

Unit 4: *Group Discussion (GD)* ***(8 hours)***
Nature of group discussions uses and importance; Leadership function in GD; developing leadership qualities and positive group behaviour; Starting discussions: opening the discussion, stating objectives, suggesting good group procedure (time management, speaking procedure, etc.; giving opinions, asking for opinions and supporting opinions in GD; making suggestions and asking for suggestions; Balancing points of view, expressing advantages, disadvantages and consequences; some pitfalls in discussions, fallacies in argument and rebuttal, concluding and controlling discussions.

Suggested Materials & References

Brigitte Markner-Jäger, 2008. Technical English for Geosciences, A Text/Work Book, Springer
David Horner & Peter Strutt, 1996. Words at work, Vocabulary development for Business English, Cambridge University Press
Durant, Will, 1926. The Story of Philosophy, Simon & Schuster.
Fowler, H.W., 1996. Fowler's Modern English Usage, Revised third edition, edited by R.W. Burchfield, Oxford University press
Ibbotson, Mark, 2009, Professional English in Use, Cambridge University Press
Jordan, R.R., 1999. Academic Writing Course, Study skills in English, Pearson Education Limited, UK.
Kuhn, Thomas S., 1962. The Structure of Scientific Revolutions, The University of Chicago Press.
Lewis, Norman, 2011.Word Power Made Easy (Indian Publisher: GOYL SAAB)
Lewis, Norman, 1978, How to read better and faster (Indian Publisher: GOYL SAAB)
Popper, K.R., 1959. The logic of scientific discovery, Hutchinson, London.
Cambridge International Dictionary of Phrasal Verbs
Ready consultation: https://www.wikipedia.org

Semester-II

AGP-201: Geophysical Inversion

L	Cr	IS	ES	T
3	3	40	60	100

Unit 1: *Introduction to inverse theory* ***(6 hours)***
Model space and data space; Definition of the forward and inverse problems; Continuous and discrete inverse problems; Mathematical background; Rank of a matrix; Eigenvalues and eigenvectors; Inverse of a matrix; Singular Value Decomposition (SVD); Probability; A priori information.

Unit 2: *Linear inversion* ***(8 hours)***
Formulation of linear inverse problems; Least squares method: steepest descent and conjugate gradient; Norms; Misfit; Gradient and Hessian; Overdetermined and underdetermined; Existence, uniqueness and stability; Tikhonov regularization; Variance and prediction error; Generalized inverses; Maximum likelihood solution; Examples.

Unit 3: *Non-linear inversion* ***(8 hours)***
Newton's method; Gauss-Newton (GN) and Levenberg-Marquardt (LM) methods; Occam's inversion; Parameterizations; Linearizing parameterizations; Convergence and nonuniqueness; Examples.

Unit 4: *Probabilistic inversion* ***(5 hours)***
Bayesian approach; Prior and posterior distributions; Sampling methods: Rejection sampling, Markov chain Monte Carlo.

Unit 5: *Global optimization* ***(3 hours)***
Particle Swarm Optimization (PSO); Simulated annealing; Genetic algorithm; Neighbourhood algorithm.

References:

1) Menke, W. (2018). *Geophysical Data Analysis: Discrete Inverse Theory*. Academic Press.
2) Aster, R.C., Borchers, B., and Thurber, C.H. (2013). *Parameter Estimation and Inverse Problems*. Academic Press.
3) Tarantola, A. (2005). *Inverse Problem Theory and Methods for Model Parameter Estimation*. SIAM.
4) Scales, J.A., Smith, M.L. and Treitel, S. (2001). *Introductory Geophysical Inverse Theory*. Samizdat Press.
5) Gubbins, D. (2004). *Time Series Analysis and Inverse Theory for Geophysicists*. Cambridge University Press.
6) Wunsch, C. (2006). *Discrete Inverse and State Estimation Problems*. Cambridge University Press.

AGP-202: Geophysical Prospecting.

L	Cr	IS	ES	T
3	3	40	60	100

Unit 1: *Subsurface studies-issues at different depths* ***(4 hours)***
Geophysical problems in different depth ranges - Shallow subsurface, basin-scale, plate scale and deeper; Building blocks of geophysical concepts - Contrast, anomaly and overburden; Forward problems and inverse problems, layers and boundaries, geophysical models, causative bodies and their geometrical analogy

Unit 2: *Geophysical properties of sediments, rocks and minerals* ***(6 hours)***
Pore space properties, Densities, Magnetic susceptibilities, electrical potential differences having different origins, electrical resistivities, dielectric constants, velocities of seismic waves, reflection coefficients, Radioactive properties, Thermal Properties, contrasts and anomalies, Geophysical anomalies for different geological situations.

Unit 3: *An introduction to Exploration Geophysics* ***(8 hours)***
The questions frequently faced by the geophysicists, the nature of geophysical problems, Fields of Exploration Geophysics: Regional geophysics, Oil and gas geophysics, Ore geophysics, Groundwater geophysics, Engineering geophysics,

Unit 4: *Geophysical Field Practices* ***(6 hours)***
Problem types and planning for data acquisition; Random data collection and systematic data collection on grids; means to bring random data on grids; Resolution - vertical and horizontal; Drift correction for gravity data; Misties and their removal from the airborne magnetic data; Sounding and Profiling; Different types of array designs used for electrical and electro-magnetic surveys; Pseudo-sections and electrical tomography; 2D and 3D seismic data acquisition; Multi-component Seismics

Unit 5: *Elements of open-hole wireline logging* ***(6 hours)***
Borehole environment; Significance of different types of resistivities; Archie's equations for sandstones and carbonates; General methods of qualitative and quantitative interpretations; introductory aspects of log correlation using sequence stratigraphic approach

Suggested materials and references

1. Adams, S., Lambert, D., Earth Science: An Illustrated Guide to Science, Chelsea House Publishers, 2006.
2. Dobrin, M.B., Savit, C.H. Introduction to Geophysical Prospecting, 4th Ed. McGraw Hill, 1988.
3. Dewan, J. T., Essentials of Modern Open-hole Log Interpretation, PennWell Books, 1983.
4. Kearey, P., Brooks, M., Hill, I. An Introduction to Geophysical Exploration, 3rd Ed. Blackwell, 2002.
5. Lowrie, W., Fundamentals of Geophysics, 2nd edition, Cambridge University Press, 2007.
6. Milsom, J., Eriksen, A., Field Geophysics, John Wiley & Sons, 2011.
7. Mussett, A. E., Khan, M.A., Looking into the earth: An introduction to geological geophysics, 1st Published, Cambridge University Press, 2000.
8. Rider, Malcolm, The Geological Interpretation of Well Logs, 2nd Edition, Rider-French Consulting Ltd, Scotland, 2002.
9. Robinson, E.S., Coruh, C., Basic Exploration Geophysics, 1st ed., Wiley, 1988.
10. Stein, S., Wysession, M., An Introduction to Seismology, Earthquakes and Earth Structure, Blackwell, 2003.
11. Williams, L., Earth Science Demystified, McGraw-Hill, 2004

AGP-203: Geophysical Signal Theory

L	Cr	IS	ES	T
3	3	40	60	100

Unit 1: *Digital Signals* ***(6 hours)***
Classification of digital signals, Wavelets, Convolution, Properties of convolution, Transfer function for a causal system, Transfer function for a non-causal system, Laplace Transform and z-transform, The inverse z-transform.

Unit 2: *Frequency Analysis* ***(6 hours)***
Frequency domain representation of Digital Signals and Systems, Fourier Transform for Discrete-Time Signals, Properties of the Fourier Transform, Minimum delay and Minimum phase, All-Pass Systems

Unit 3: *Deconvolution* ***(6 hours)***
The Autocorrelation and the Spectrum, The cross-correlation, The Convolutional Model, Signature Deconvolution, Deterministic Reverberation Deconvolution, Predictive Deconvolution, Maximum Entropy Spectral Analysis.

Unit 4: *Optimum Linear Filtering and FK techniques* ***(6 hours)***
Least Squares Filtering, Linear Prediction, Spiking and Shaping Filters for Seismic Data, Adaptive Filtering. The FK Transform, Aliasing, FK Transforms related to seismic data, FK Filtering, FK Migration

Unit 5: *Data-Processing* ***(6 hours)***
Processes to improve the signal-to-noise ratio, Processes to reposition data, Special processing techniques, typical processing sequence and Interactive processing, Data processing of 3-D data, 3-D Migration.

References:

1. Sheriff, R.E., & Geldart, L.P., Exploration Seismology Vol. 1 & 2, Reprinted. Cambridge, 1986, 1987.
2. Telford, M., Geldart, L.P., Sheriff, R.E. and Keys, D.A., Applied Geophysics, 1st Indian ed. Oxford & IBH, 1988.
3. Yilmaz öz, Seismic Data Analysis: Processing, Inversion and Interpretation of Seismic Data, Society of Exploration Geophysics, 2000.

AGP-204: Numerical Analysis & Computer Programming

L	Pr	Cr	IS	ES	T
3	1	4	40	60	100

Unit 1: *Solution of algebraic and transcendental equations* ***(4 hours)***
Different methods like Bisection, Iteration, False Position. Newton-Raphson Method, Muller's Method, The Quotient-Difference Method, Solution of Systems of Nonlinear Equations.

Unit 2: *Interpolation* ***(6 hours)***
Forward differences, Backward differences, Central differences; Detection of errors by use of Difference tables; Differences of a polynomial; Gauss's Central Difference formulae, Stirling's, Bessel's, Everett's formula; Lagrange's Interpolation Formula, Hermite's Interpolation Formula; Newton's General interpolation formula; Interpolation by iteration; Method of successive approximations

Unit 3: *Numerical solution of differential and integral equations* ***(8 hours)***
Numerical solution of ordinary differential equations (Solution by Taylor's Series, Picard's Method of Successive Approximations, Euler's Method, Runge-Kutta Methods, Adams-Moulton Method, Milne's Method), Numerical solution of partial differential equations (Laplace's equation, Jacobi's Method, Gauss-Seidel Method, Iterative methods for the solution of equations), Numerical Solution of Integral equations (Finite difference methods, A method of degenerate Kernels, Method of Invariant Imbedding, Method using generalized quadrature)

Unit 4: *Fundamental concepts related to Computer Programming* ***(4 hours)***
The architecture of digital computers, number systems, data representation, binary arithmetic, Classification and overview of operating system modules; Introduction to UNIX and LINUX operating systems, Window environment, algorithm and flowcharts

Unit 5: *FORTRAN and C languages* ***(8 hours)***
FORTRAN: Control structures- selective and repetitive, arrays, format statements; subprogram functions, subroutines, DATA, SAVE, COMMON and EQUIVALENCE statements; file processing; additional data types, logical, double precision and complex types.
C: Introduction, constants, variables and data types, operators and expressions, I/O operations, decision making and branching; decision making and looping; arrays, structures and unions, user-defined functions, pointers, file management, dynamic allocations and linked lists, the preprocessors.

AGP-204-P: Practical: Numerical Analysis & Computer Programming

L	Cr	IS	ES	T
2	1	20	30	50

1. Numerical solution of non-linear algebraic and transcendental equation by bisection, iteration, false position, secant and Newton Raphson methods
2. Numerical solution of a system of linear simultaneous equation by Gauss elimination and Gauss-Seidel methods
3. Interpolation by Lagrange's interpolation formula
4. Numerical evaluation of definite integral by Trapezoidal, Simpson's $1/3^{rd}$, Simpson's $3/8^{th}$, Weddle and Gaussian quadrature formulae.
5. Numerical solution of first-order ordinary differential equation by Euler's Modified Euler's second and fourth-order Runge-Kutta, Adams-Moulton and Milne's methods.
6. For FORTRAN Language: Execution of programs using the following:
   i) Control Structures – Logical IF, Arithmetic IF, Nested Block IF, Computer GOTO
   ii) Repetitive Structures – IF loop, DO-loop, Nested DO loop
   iii) Arrays – Traversing, Sorting, Searching, Inserting, deleting operations, Use of two or more dimensional arrays
   iv) Subprograms: Functions – Statement functions, Function Subprograms, Subroutine Subprograms
   v) Use of DATA, SAVE, COMMON and EQUIVALENCE statements
   vi) File processing
7. For C-Language: Execution of programs using the following:
   i) Decision making and branching- if statement, Nested if, Else if ladder, Block if, Switch statement
   ii) Decision making and looping – while, do-while, for.
   iii) Arrays- Traversing, Sorting, Inserting, deleting operations, Processing arrays with more than one dimensions
   iv) User-defined functions – Recursive functions, Nesting of functions
   v) Structures – Use of structure data type, an array of structures, Unions.
   vi) Handling files in C-sequential, random access files.

AGP-2D-1: Hydrogeology and Groundwater Investigations

L	P	Cr	IS	ES	T
3	1	4	40	60	100

Units	Hydrogeology and Groundwater Investigations
1	Definition of Hydrology and its relation with other sciences. Hydrologic cycle. Origin, occurrence and distribution of subsurface water. Porosity and different types of pore spaces in rocks. ***(2 hours)***
2	Concept of water table and piezometric surface. Importance of water table in hydrogeological studies. Aquifer - its definition, different types and characteristics. ***(6 hours)***
3	Dynamics of subsurface water: Darcy's law and its range of validity. Basic concepts of permeability/hydraulic conductivity, specific yield, transmissivity and storage coefficient. ***(6 hours)***
4	Basics of well hydraulics related to a pumping well: Concepts of drawdown, cone of depression, specific capacity, specific drawdown and boundary conditions. Equilibrium and non-equilibrium conditions. ***(6 hours)***
5	Groundwater investigations: Geological, hydrogeological and geophysical approaches; Groundwater inventory. Study of flow nets and its importance in groundwater investigation. Hydrogeological studies carried out in drilled wells. ***(6 hours)***
6	Basic concept of groundwater management - equation of hydrologic equilibrium. Safe yield and overdraft. ***(4 hours)***

Suggested Books:

1) **Groundwater Hydrology** (2nd Edn) - D.K. Todd, *John Wiley & Sons, New York*
2) **Hydrogeology** - Davis, S. N., and DeWiest, R. J. M., *John Wiley & Sons, New York*
3) **Ground Water** - *H.M. Raghunath* (1983), Wiley Eastern Ltd., New Delhi
4) **Introduction to Ground Water Hydrology** - R.C. Heath and F.W. Trainer, John Wiley & Sons, New York.
5) **Ground Water Assessment Development and Management** - *K.R. Karanth,* (1987), *Tata McGraw-Hill, New Delhi*
6) **Hydrogeology Principles and Practice** - *K. M.Hiscock*, (2005), *Blackwell Publishing*

AGP-2D-2: Principles of Stratigraphy

L	Cr	IS	ES	T
4	4	40	60	100

Units	Topic
1.	Principles of stratigraphy, Modern development in stratigraphy, Steps in stratigraphic studies. Evolution of Geological Time Scale. Significant events in geological time. ***(4 hours)***
2.	Formal stratigraphic classifications: rock, time and time-rock units. The Stratigraphic Code, Local Example: The Jaintia Group. Lithostratigraphy. Biostratigraphy, Chronostratigraphy, Magnetostratigraphy. ***(6 hours)***
3.	Methods of Correlation: physical and time (isochronous/ diachronous patterns), Correlation of lithostratigraphic units, Shaw's Graphic correlation. Sediment accumulation and gaps in the stratigraphic record: diastems, unconformities. ***(6 hours)***
4.	Stratotypes, Facies in stratigraphy. Walther's Law of succession of facies. Types of Stratigraphic facies. ***(4 hours)***
5.	Stratigraphy and Distribution of Tertiary rocks of upper Assam and Surma basins, Assam Arakan Mobile Belt, Meghalaya Basin and Arunachal foredeep. ***(6 hours)***
6.	Generalised stratigraphic successions of different petroliferous basins of India. ***(4 hours)***

Reference:

1) Sam Boggs, 1995, Principles of Sedimentology and Stratigraphy Prentice Hall, New Jersey, 765p.
2) Mial A.D. 1999. Principles of Sedimentary Basin Analysis. 3rd edition. Springer-Verlag.
3) Schoch, R. M. 1989. Stratigraphy, principles and methods.
4) Weller, J. Marvin 1960. Stratigraphic principles and practice. Harper's Geoscience series.
5) Krishnan, M.S. 1982. Geology of India and Burma, CBS Publishers, Delhi

Semester III

AGP-301: Seismology

L	Cr	IS	ES	T
3	3	40	60	100

Unit 1: *Introduction*
Earthquake and its effects; Various magnitude scales and their limitations; Intensity scales; Earthquake frequency; Energy released in an earthquake; Impacts and assessments of earthquakes; Causes of intra and interplate earthquakes; Classification of earthquakes; Determination of earthquake parameters; Seismicity and seismotectonics of India and Himalayas.

Unit 2: *Elasticity theory and seismic waves*
Elastic, anelastic and plastic behaviour of materials; the stress matrix, the strain matrix, the elastic constants; generalized Hooke's law; different types of elastic waves and their propagation characteristics; equations of motion of seismic body waves; Attenuation and dispersion of seismic waves; free oscillations of the earth.

Unit 3: *Instruments*
Amplitude and phase characteristics of seismometers; short period, long period and broadband seismometers; analysis of seismograms and identification of various phases on the seismograms; basic principle of the strong-motion instrument.

Unit 4: *Seismology and earth's interior*
Ray characteristics and related parameters for horizontally and spherically stratified earth; basic principles of seismic tomography and receiver function analysis; location of the epicentre of an earthquake; global seismicity; elastic rebound theory; fault-plane solutions and related interpretation; reflections and refractions in the earth's interior; models of the earth's internal structure.

Unit 5: *Earthquake monitoring and prediction*
Seismic networks and arrays, standalone and telemetry systems, the study of microearthquakes and induced seismicity, Earthquake prediction: Dilatancy theory, short-term, middle-term and long-term prediction.

Reference:

1. Anderson, Don L., Theory of the Earth, Blackwell Scientific Publications, 1989.
2. Gupta, Harsh K. (Edited), Encyclopedia of Solid Earth Geophysics, Springer
3. Havskov Jens, Alguacil Gerardo, Instrumentation in Earthquake Seismology, 2002
4. Kayal, J.R., Microearthquake Seismology and Seismotectonics of South Asia, Springer, 2008.
5. Lowrie, W., Fundamentals of Geophysics, 2nd edition, Cambridge University Press, 2007.
6. Müller Gerhard, Theory of Elastic Waves, 2007.
   Source: http://gfz-potsdam.de/mhw/tew
7. Shearer, Peter M., Introduction to Seismology, Cambridge University Press, 2009
8. Stein Seth, Wysession Michael, An Introduction to Seismology, Earthquakes and Earth Structure, Blackwell, 2003.

AGP-302: Geophysical Tools I: Seismic Methods (Data Acquisition & Processing)

L	Cr	IS	ES	T
3	3	40	60	100

Unit 1: *Seismic Methods-Fundamental theories*
Types of seismic waves, Attenuation, Reflection, Refraction and Diffraction of elastic waves, Effects of the medium on wave propagation, Partitioning of energy at an interface, Geometry of seismic wave paths for several horizontal and dipping beds, Distinguishing features of seismic events, Events other than primary reflections, Characteristics of reflections, Types of seismic noise and their attenuation.

Unit2: *Seismic Refraction Data Acquisition*
In-line reversed refraction profiling, Broadside refraction and fan shooting' Engineering applications of refraction methods, Dam site surveys, Refractions for studying the Earth's interior.

Unit 3: *Land Seismic Reflection Data Acquisition*
Field Layouts: Split-dip and common-depth-point recording, Spread types, Arrays, Noise analysis, selection of field parameters, Uphole surveys, Crooked line and 3-D methods
Equipment for land surveys: Surface energy sources, Geophones, Amplifiers, Analog data recording, Digital recording

Unit 4: *Marine Seismic Reflection Data Acquisition*
Marine equipment and methods: Marine operations, Bubble effect, Marine energy sources, Marine detectors, Marine positioning

Unit 5: *Other upcoming techniques of Seismic Data Acquisition*
Multi-component seismic data acquisition, Vertical Seismic Profiling (VSP), Seismic Tomography, 4-D Seismic, Passive Seismic Techniques

Unit 6: *Data-Processing*
Processes to improve signal-to-noise ratio, Processes to reposition data, Special processing techniques, typical processing sequence and Interactive processing, Data processing of 3-D data, 3-D Migration.

References:

1. Lowrie, W., Fundamentals of Geophysics, 2nd edition, Cambridge University Press, 2007.
1. Telford, W.M., Geldart, L.P., Sheriff, R.E., 1990. Applied Geophysics, Second Edition, Cambridge University Press.
2. Dobrin, M.B., Savit, C.H. Introduction to Geophysical Prospecting, 4th Ed. McGraw Hill, 1988.
3. Sheriff, R.E., & Geldart, L.P., Exploration Seismology Vol. 1 & 2, Reprinted. Cambridge, 1986, 1987
4. Robinson, E.S., Coruh, C., Basic Exploration Geophysics, 1st ed., Wiley, 1988.

AGP-303: Geophysical Tools II: Electrical & Electro-Magnetic Methods

L	Cr	IS	ES	T
3	3	40	60	100

Unit 1: *Self-potential method* ***(4 hours)***
Origin of self-potentials; Electrochemical reactions; field measurements; self-potential response over typical geometrical bodies; Fluctuation of SP with time and the associated corrections; Interpretation of SP anomalies

Unit 2: *Electrical resistivity surveying* ***(18 hours)***
Current flow across a boundary, Measuring resistivity; Equipment for electrical resistivity surveying; Vertical Electrical Sounding (VES) and profiling; Different types of array designs; Choice of arrays for different geological situations; Forward and Inverse methods of resistivity data interpretation; Resistivity profiles over faults and dykes; Applications of linear filter theory; determination of filter coefficients; sinc response filter length; Recurrence relations: Flathe and Pekeris relations; determination of resistivity transforms; Potential due to a point source in an anisotropic medium; triangle of anisotropy; Dar Zarrouk parameters; the principle of equivalence; Resistivity modelling

Unit 3: *Mise-a-la-masse method* ***(4 hours)***
Principle of the method; Theoretical considerations for different shapes of ore bodies; Laboratory scale model studies; Correlation ore bodies between the boreholes; Determination of direction and velocity of groundwater flow, Field examples.

Unit 4: *Induced polarization surveying* ***(4 hours)***
Source of induced potential, time domain and frequency domain measurements of IP, chargeability, per cent frequency effect and metal factors, Plotting of IP surveying data in pseudo-sections, Comparison of resistivity data with IP data, Field examples.

Unit 5: *Electromagnetic surveying* ***(10 hours)***
Principle of electromagnetic induction; magnetic field due to current carrying loop, elliptical polarization, the plane of polarization, dip and tilt angles, nomograms for the quantitative determination of parameters by dip angle method, VLF and AFMAG methods, TURAM method. Basic principles of transient electromagnetic methods, a brief account of various time-domain systems, frequency sounding and geometric sounding, merits of time-domain methods over frequency-domain methods.

References:

1. Bhattacharya, B.B., Shalivahan, 2016. Geoelectric Methods, Theory and Applications, McGraw Hill Education (India) Private Limited, New Delhi.
2. Telford, W.M., Geldart, L.P., Sheriff, R.E., 1990. Applied Geophysics, Second Edition, Cambridge University Press.
3. Reynolds, J.M., 2011. An Introduction to Applied and Environmental Geophysics, 2nd edition, Wiley-Blackwell
4. Robinson, E.S., Coruh, C., Basic Exploration Geophysics, 1st ed., Wiley, 1988.
5. Nabighian, M.N., 1991, Electromagnetic Methods in Geophysics, Volume 2, Parts A and B, SEG Publication

AGP-304: Image Processing & Geographic Information System

L	Cr	IS	ES	T
3	3	40	60	100

Unit 1: *Introduction- Basics of surveying techniques & Physics of remote sensing*
Basics of survey techniques; Concept of projection systems; Modern survey equipment. Electromagnetic Radiation (EMR) and its spectrum; sources of EMR and governing laws; interaction of EMR with atmosphere and surface of the earth; Atmospheric windows; spectral signature and spectral reflectance, spectral responses of vegetation, water, soil etc.

Unit 2: *Remote sensing data acquisition system*
Platforms (Ground borne, airborne and spaceborne platforms; importance of various platforms concerning remote sensing of earth resources), Data acquisition (Types of sensors, photographic, single and multi-band optomechanical, thermal sensors) LISS and sensor array (their principle and operations; spectroradiometers), Microwave sensors (SLAR and SAR Systems), Spectral and spatial resolutions (Applications of different sensor bands, important Remote Sensing Satellites-LANDSAT, SEASAT, SPOT, IRS and IKONOS.

Unit 3: *Elements of Image Processing*
Structure of Remote Sensing Images, Data format BIL, BSQ and BIP, type of data products. Image Processing technique as applied to satellite image data. Image restoration, reduction, magnification, contrast enhancement (linear and non-linear), histogram equalization, rationing, filtering and edge enhancement, Vegetation indices, Georeferencing of maps and satellite images, Principle of thematic information extraction and image classification techniques, supervised and unsupervised classification, ancillary and contextual data in the classification process, the principle of change detection, registration, image differencing, image processing system consideration and characteristics.

Unit 4: *Fundamentals of Geographic Information System (GIS)*
Functional elements of GIS, map projection, data structure, comparison of raster and vector data model, data acquisition, data input and data processing, data management system, product and report generation.

Unit 5: *Applications of Remote Sensing and GIS*
Fundamentals of geological interpretation of aerial and satellite photo images based on image and terrain elements including spectral signatures, identification of rock types and mapping, mapping of local and regional structural features such as fault, fractures, folds, joints. Linear, curvilinear and circular features and their significance in oil exploration, geological guides, anomalies for mineral and oil prospecting including surface alteration and their manifestation on remote sensing images. Remote sensing applications in water resources and environmental impact assessment studies.

AGP-301-P: Practical: Seismology

L	Cr	IS	ES	T
2	1	20	30	50

AGP-302-P: Practical: Geophysical Tools I: Seismic Methods (Data Acquisition & Processing)

L	Cr	IS	ES	T
2	1	20	30	50

AGP-303-P: Practical: Geophysical Tools II: Electrical & Electro-Magnetic Methods

L	Cr	IS	ES	T
2	1	20	30	50

AGP-304-P: Practical: Image Processing & Geographic Information System

L	Cr	IS	ES	T
2	1	20	30	50

AGP-3D-1: Decision Analysis and Value of Information

L	Cr	IS	ES	T
4	4	40	60	100

Unit 1: *Basics of decision analysis* ***(8 hours)***
Uncertainties, decisions and prospect values; Decision trees; Flipping the tree: Bayes' rule; Certain equivalents; Perfect information and imperfect information; Value of Information (VOI); VOI for a univariate Gaussian case.

Unit 2: *Directed Acyclic Graphs* ***(8 hours)***
Bayesian networks; Influence diagrams; Examples.

Unit 3: *VOI in spatial problems* ***(8 hours)***
Characteristics of spatial VOI problems; Spatial VOI framework.

Unit 4: *VOI estimation methodologies* ***(8 hours)***
Rigorous Monte Carlo methodology; Simulation-regression methodology.

Unit 5: *Applications of VOI to geosciences* ***(8 hours)***
Examples from petroleum exploration and development, mining and environmental sciences.

References:

1) Eidsvik, J., Mukerji, T. and Bhattacharjya, D. (2016). *Value of Information in the Earth Sciences: Integrating Spatial Modeling and Decision Analysis*. Cambridge University Press.
2) Howard, R.A. and Abbas, A.E. (2015). *Foundations of Decision Analysis*. Pearson.
3) Pyrcz, M.J. and Deutsch, C.V. (2014). *Geostatistical Reservoir Modeling*. Oxford University Press.
4) Cressie, N. and Wikle, C.K. (2011). *Statistics for Spatio-Temporal Data.* Wiley.

AGP-3D-2: Fluvial Dynamics and Tectonic Geomorphology

L	Cr	IS	ES	T
4	4	40	60	100

Unit 1: *An introduction to fluvial processes*
Basic Principles involving physical quantities like Bed shear stress, Stream power etc. and categories of physical equations like Regression equations, equations involving the balance of forces, and fluxes, conservation equations and diffusion equations; Controlling factors and process-based classification of alluvial channels.

Unit 2: *Water flow and sediment dynamics in alluvial channels*
Basic concepts on the properties of fluids, boundary layers and flow resistance, Keulegan equation, Flow turbulence, Vortices and coherent flow structures; Sediment properties, the processes of erosion and sediment transport, bedload transport, Spatial and temporal variations in suspended sediment; Flow and sediment dynamics in curved, braided, and confluent channels

Unit 3: *Geomorphic Indices of Active Tectonics*
Hypsometric Curve and Hypsometric Integral, Drainage basin asymmetry, Stream Length – Gradient Index, Mountain-Front sinuosity, Ratio of Valley-Floor width to Valley height, Classification of relative tectonic activity.

Unit 4: *Neotectonics and landscape responses*
Basic drainage patterns and their geologic significance, drainage anomalies due to active tectonics – forward approach and inverse approach; channel classification based on sediment loads, effects of valley slope and sediment load variability on sinuosity; river responses to syn-tectonic deformations, Plano-temporal variability in the aggradation/degradation of braided rivers due to valley floor uplift/subsidence; meandering channel responses to uplift/subsidence; bankline migration and channel avulsion in the foreland basins; use of shallow subsurface investigation geophysical tools in locating palaeo-channels and mapping patterns and directions of shifting of rivers; river responses to syn-tectonic deformation with case-studies from Assam.

Unit 5: *Tectonic Geomorphology at Quaternary time scales*
Classical models of tectonic forcing and landscape responses; Landforms of strike-slip, normal and reverse faulting; Tectonic geomorphology of active folds; Evidence for Paleo-earthquakes, rates of erosion and uplift; Quaternary deformation and landscape responses; Case studies.

References:

1) André Robert (2003). *River Processes-An Introduction to Fluvial Dynamics.* Published by Arnold, London (http://www.arnoldpublishers.com) Distributed in the USA by Oxford University Press.
2) Douglas W. Burbank & Robert S. Anderson (2012). *Tectonic Geomorphology*, 2nd edition, Wiley-Blackwell.
3) Edward A. Keller & Nicholas Pinter (1996). *Active Tectonics- Earthquakes, Uplift, and Landscape*, Prentice-Hall.
4) John S. Bridge (2003). *Rivers and Floodplains – Forms, Processes, and Sedimentary record*, Blackwell Publishing
5) William B. Bull (2007). *Tectonic Geomorphology of Mountains: A New Approach to Paleoseismology*, Blackwell Publishing.
6) Stanley A. Schumm, Jean F. Dumont & John M. Holbrook (2000). *Active Tectonics and Alluvial Rivers*, Cambridge University Press.

Edited Volumes:

1) *Large Rivers-Geomorphology and Management*, Edited by Avijit Gupta (2007), John Wiley & Sons, Ltd.
2) *Tectonic Uplift and Climate Change*, Edited by William F. Ruddiman (1997), Plenum Press, New York and London
3) *Geomorphology and Global Tectonics*, Edited by Michael A. Summerfield (2000), Wiley.
4) *Fluvial Sedimentology VI* – Special Publication Number 28 of the International Association of Sedimentologists (1999) – Edited by N.D. Smith and J. Rogers, Blackwell Science.
5) *Fluvial Sedimentology VII* – Special Publication Number 35 of the International Association of Sedimentologists (2005) – Edited by Michael D. Blum, Susan B. Marriott and Suzanne F. Leclair, Blackwell Publishing

AGP-3G-1: Water Science, Policy & Governance

L	Cr	IS	ES	TM
4	4	40	60	100

Unit 1: *Water- the major issues* ***(6hrs)***
The water crisis; Importance of studying water; Current global water balance; Water as the critically important driver of socio-economic growth; Trans-boundary conflicts; Conflicts within the States of India; River basin politics; Integrated Water Resources Management (IWRM) at different levels; Traditional water harvesting techniques and their efficacies; International Organizations and Water Policy debates; Distribution and Classification of Aquatic Ecosystems; Drivers of Change in Inland Aquatic Ecosystems.

Unit 2: *Water and different branches of science* ***(10hrs)***
Global hydrology; The Earth System and Water; Water Reserves, Fluxes and Residence Time; Global water cycle; Global water-balance requirements; Precipitation, observation and measurement; Precipitation modelling; Precipitation and engineering design; Trends and variability in Global Evaporation; Interception; Infiltration; Observation of Hydrological Processes using Remote Sensing; Hydrogeophysics, Geophysical methods, Case Studies; Hydrological modelling; Uncertainty of Hydrological Predictions; Water Chemistry and management of wastewater; Water biology; Quality of drinking water analysis.

Unit 3: *Surface water* ***(6hrs)***
The Hydrodynamics and morphodynamics of Rivers, Lakes and Reservoirs; Hydrology and ecology of river systems; Flood and bank erosion-Causes and Effects; Urban floods and the nuisance created thereby; sediment budgeting; Artificial Embankments and River bed-river bank dynamics; Incubation and triggering of flood disasters; Flood Disaster Risk Reduction. -

Unit 4: Groundwater ***(10hrs)***
Origin and age of groundwater; rock properties affecting groundwater; geologic formations as aquifers; Types of aquifers; Groundwater movement; Darcy' Law; Permeability; flow rates; flow directions; Groundwater levels and environmental influences; Quality of groundwater; Pollution of Groundwater; Pollutants in groundwater of Assam and the impact of water pollution on health and the remedial measures; Surface and subsurface geophysical investigations of groundwater; Artificial recharge of groundwater; Saline water intrusion in Aquifers.

Unit 5: *Water and the society* ***(8hrs)***
Water as an Economic Good - Old and new concepts; Water Supply and Demand; International and National Water Policies; Managing surface water; Managing Groundwater; Water in the Industry; Water availability and its use in agriculture; Ramsar Convention on Wetlands; Groundwater sustainability and future management issues; Types of governance for river basin management; Effective uses of inland waterways; Basin governance challenges; Reconceptualizing water governance

References:

1. Aswathanarayana, U., 2005. Advances in Water Science Methodologies, Taylor and Francis.
2. Fetter, C.W., Applied Hydrogeology, 4th Edition, Prentice-Hall.
3. Spellman, Frank R., 2008. The Science of Water: Concepts and Applications, 2nd Edition, Taylor & Francis Group.
4. Todd, David Keith. and Mays, Larry W. 2005. Groundwater Hydrology, 3rd Edition, John Wiley & Sons.
5. Wilderer, Peter (Editor-In-Chief), 2011. Treatise on Water Science, 4 Volumes, Elsevier.

Semester IV

AGP-401: Geophysical Tools III: MT & GPR Methods

L	Cr	IS	ES	T
3	3	40	60	100

Unit 1: *Magneto Telluric Methods-Theoretical issues* ***(8 hours)***
Sources of MT signal; Cagniard's relations for depth of penetration and resistivity of the medium; Interaction of MT field with the earth - uniform earth, horizontal layers, anisotropy, inhomogeneity; impedance tensor and tipper; topographic and regional effects; static shift.
Theory of electromagnetic wave propagation in horizontally layered earth and response over multi-layered earth; skin depth for homogeneous and layered earth.
Audio magnetotelluric methods (AMT)

Unit 2: *Magneto Telluric Data processing and analysis* ***(4 hours)***
Auto and cross spectra, the solution to the impedance and tipper equations, local and remote references, errors and noise. Robust and hybrid processing.

Unit 3: *Magneto Telluric Data Interpretation and Case histories* ***(8 hours)***
Interpretation of MT data over two-layered earth, strike, rotation swift strike, polar diagram, tipper, skew, ellipticity, TE and TM modes; continental lower crust, MT study over cratons; Field examples showing structural mapping for petroleum exploration, geothermal mapping, exploration for sulphides, gold, uranium; Detecting subsurface structure and water.

Unit 4: *Basics of Ground Penetrating Radar* ***(5hours)***
Areas of applications, Principles of operation, Propagation of radio waves, Dielectric properties of earth materials, Basic similarity with seismic, antennas, pulse width and central frequency, time windows and samples; propagation of electromagnetic waves in the group – Q and loss tangent, reflection and transmission coefficients

Unit 5: *GPR Applications and Data Interpretation* ***(5hours)***
Field procedure and interpretation: monostatic and bistatic arrangements, profiling and stacking, reflection and diffraction, distance determination, migration; depth of penetration and resolution, vertical and lateral resolution; fracture mapping; structures in sand and moraines; Glacial geological investigations; groundwater investigations; Civil engineering problems; applications in Archaeology.

References:

1. Berdichevsky, M.N., Dmitriev, V. I., 2008. Models and Methods of Magnetotellurics, Springer.
2. Hauck, C., Kneisel, C., 2008. Applied geophysics in Periglacial Environments, Cambridge University Press.
3. Reynolds, J.M., 2011. An Introduction to Applied and Environmental Geophysics, 2nd edition, Wiley-Blackwell.
4. Simpson, F., Bahr, K., 2005. Practical Magnetotellurics, Cambridge University Press.
5. Telford, W.M., Geldart, L.P., Sheriff, R.E., 1990. Applied Geophysics, Second Edition, Cambridge University Press.
6. Vozoff K.,1991. The magnetotelluric method. In: Nabighian M (ed) Electromagnetic methods in applied geophysics II. Society of Exploration Geophysicists, Tulsa Oklahoma.
7. Zhdanov, Michael S., 2009. Geophysical Electromagnetic Theory and Methods (Methods in Geochemistry and Geophysics, 43), Elsevier.

AGP-402: Geophysical Tools IV: Gravity & Magnetic Methods

L	Cr	IS	ES	T
3	3	40	60	100

Unit 1: *Gravity Methods* ***(5 hours)***
The Earth's gravitational field and its relation to gravity exploration; Gravitational effects over subsurface bodies having discrete shapes; Instruments for measuring gravity on land, at sea and into the boreholes; Gravity measurements on land, at sea and airborne gravity surveys.

Unit 2: *Magnetic Prospecting* ***(5 hours)***
The magnetism of the earth; Magnetic susceptibility of rocks; Magnetic effects from buried magnetic bodies; Instruments used for magnetic measurements; Magnetic surveys on land, Marine and airborne magnetic data collection

Unit 3: *Gravity data processing and interpretation* ***(8 hours)***
Reductions of gravity data and interpretation of Bouguer anomaly maps; analytic methods for separation of regional and residuals; ambiguity in gravity interpretation and conditions for unique interpretation; upward and downward continuations of gravity anomalies; calculation of second vertical derivatives and horizontal gravity gradients, the utility of such maps; gravity effects due to 2D and 3D bodies having irregular shape; Methods for basement mapping; use of gravity survey in mineral and hydrocarbon exploration programs, search for metallic and nonmetallic ores, coal and lignite; mapping faults, exploration for salt domes, stratigraphic traps, uplifted horst and graben, use of gravity in regional geological studies including granitic plutons, thrust belts, case histories.

Unit 4: *Magnetic data processing and interpretation* ***(6 hours)***
Reduction of magnetic data; preparation and interpretation of anomaly maps; Interpretation of aeromagnetic maps; Werner and Euler Deconvolution, analytical signal, Source parameter imaging; 2D andmodellingling; spectral analysis for depth determination; the utility of aeromagnetic maps in mineral and hydrocarbon exploration programs and regional studies; case histories.

Unit 5: *New Frontiers- Gravity Gradiometry* ***(6 hours)***
The Gravity Tensor; Principles of gravity gradiometry; interpreting tensor components; airborne gravity gradiometry; imaging techniques for Full Tensor Gravity Gradiometry (FTGG) data, gravity gradiometer survey error, advantages of gravity gradiometry; detectability of mineral deposits with airborne gravity gradiometry; gravity gradiometry in oil exploration; case histories.

References:

1. Blakely, Richard J., Potential theory in gravity and magnetic applications, 1st Published, Cambridge University Press, 1995.
2. Dobrin, M.B., Savit, C.H. Introduction to Geophysical Prospecting, 4th Ed. McGraw Hill, 1988.
3. Lowrie, W., Fundamentals of Geophysics, 2nd edition, Cambridge University Press, 2007.
4. Mussett, A. E., Khan, M.A., Looking into the earth: An introduction to geological geophysics, 1st Published, Cambridge University Press, 2000.
5. Robinson, E.S., Coruh, C., Basic Exploration Geophysics, 1st ed., Wiley, 1988.
6. Telford, W.M., Geldart, L.P., Sheriff, R.E., 1990. Applied Geophysics, Second Edition, Cambridge University Press.

AGP-403: Geophysical Tools V: Well Logging

L	Cr	IS	ES	T
3	3	40	60	100

Unit 1: *Introduction to Geophysical Well Logging* ***(5 hours)***
Why well logging? History of well logging; Borehole environment; Rock composition – matrix, sand , shale, limestone, clay minerals and formation fluids; porosity of rocks – classification, packing of grains; permeability – absolute, effective and relative; permeability associated with fractures; resistivities of rocks – their dependence on salt concentration in water; the relationship between permeability and porosity; The relationship between porosity and resistivity (the formation factor); The relationship between saturation and resistivity (Archie's formula); classification of log measurements; Problems specific to well-log measurements; Log presentation.

Unit 2: *The logging environment* ***(3 hours)***
Introduction; pressure environments of borehole logging and invasion; temperature environment of borehole logging; logging tool capabilities; borehole depth measurement; borehole temperature measurement, true formation temperatures (BHT corrections); borehole size measurements by calliper logs.

Unit 3: *Permeable zone indication logs* ***(5 hours)***
Spontaneous Potential (SP): the origin of different types of potentials (electrokinetic, diffusion or liquid junction, shale or Nernst); Static SP, amplitude and shape of SP peaks; bed thickness; shale baseline shifts; Geology and the SP.
Natural Gamma radioactivity measuring logs: The origin of natural radioactivity in rocks; measurement of gamma radiation; factors affecting the gamma-ray response; bed thickness; different applications
Natural gamma-ray spectrometry: Computation of Th, U and K content; applications like
detection of unconformities, fractures, hydrocarbon potential etc.

Unit 4: *Resistivity measuring logs* ***(5 hours)***
Introduction; Non-focused long-spacing tools; Focused long spacing tools: Induction (IL), laterologs; non-focused microtools like microlog (ML); Focused microtools like the microlaterolog (MLL); spherically focused logs (SFL), Dual Laterolog-Micro spherically focused tool (DLL-MSFL), Dual induction-spherically focused logs; Geological factors which influence resistivity; applications.

Unit 5: *Porosity measuring logs* ***(8 hours)***
Neutron logs: Measurement of the apparent hydrogen index; spatial distribution of thermal neutrons and capture gamma rays; Compensated neutron tool; Geological factors affecting the hydrogen index.
Density logs: Principles related to pair production, Compton scattering, Photo-electric effect, the relation between electronic density and the bulk density; Litho-density tool; fundamental factors influencing the measurements of shales, water and hydrocarbon; Environmental effects due to the borehole, mud-cake, casing, invasion etc.; Geological factors like rock composition, rock texture, sedimentary structure, temperature, pressure, depositional environment etc.
Sonic logs: Borehole compensated sonic tool; Factors influencing the measurement like matrix, porosity and fluids, temperature and pressure; Environmental and other effects like transit time-stretching, cycle skipping, the borehole, invasion, radial cracking effects etc.
Porosity logs (Compensated Neutron tool, Compensated Sonic tool, Litho-density tool).

Unit 6: *Miscellaneous tools* ***(4 hours)***
Dipmeter; CBL/VDL; Production logging tools; Perforation practices; rock sampling; fluid sampling etc.

References:

1. Bassiouni, Zaki, Theory, Measurement, and Interpretation of Well Logs, SPE Textbook Series Vol.4, 1994
2. Brock James, Applied Open-Hole Log Analysis, Gulf Publishing Company, 1986
3. Dewan, J. T., Essentials of Modern Open-hole Log Interpretation, PennWell Books, 1983.
4. Ellis, D.V., Singer, J.M., 2008. Well Logging for Earth Scientists, 2nd Edition, Springer.
5. Rider, Malcolm, The Geological Interpretation of Well Logs, 2nd Edition, Rider-French Consulting Ltd, Scotland, 2002.
6. Schlumberger, Log interpretation principles/ Applications, 1999. Schlumberger Educational Services.
7. Serra, O., 1984. Fundamentals of well-log interpretation (1. The acquisition of logging data), Elsevier.
8. Serra, O.,1986. Fundamentals of well-log interpretation (2. The interpretation of logging data), Elsevier.
9. Telford, M., Geldart, L.P., Sheriff, R.E., Applied Geophysics, 2nd edition, Cambridge University Press, 1990.

AGP-404: Reservoir Geophysics

L	Cr	IS	ES	T
3	3	40	60	100

Unit 1: *Rock Physics* ***(8 hours)***
Basic rock physics concepts; Stress and strain; Elasticity; Effective medium models; Voigt and Reuss bounds; Hashin-Shtrikman bounds; Bounding average method; Fluid substitution; Gassmann's relations; Velocity, porosity, clay relations; Carbonates; Fluid flow and permeability; Darcy's law; Kozeny-Carman relation; Partial saturation: patchy and uniform saturation; Relative permeability; AVO: Shuey's approximation and Aki-Richard's approximation; Vp-Vs relations; Anisotropy; Fractures. Pore pressure estimation; effective stress; overburden pressure; Hydrostatic pressure.

Unit 2: *Seismic attributes from well logs* ***(3 hours)***
Exploratory data analysis; Lithofacies identification from well logs; Derived distributions of seismic attributes; Seismic well tie; Calibration of seismic data with well data.

Unit 3: *Seismic reservoir characterization* ***(6 hours)***
Seismic attributes: P-wave impedance, S-wave impedance, Vp/Vs ratio, AVO intercept (R0) and gradient (G); Monte Carlo simulation; Lithofacies and pore fluids classification; Confusion matrices; Probability maps; 3D iso-probability plots.

Unit 4: *Geostatistical simulation* ***(8 hours)***
Modelling of reservoir properties away from wells; Geostatistical simulation of reservoir properties: facies, porosity, permeability; Kriging; Two-point algorithms: sequential Gaussian simulation (SGSIM), sequential indicator simulation (SISIM), sequential indicator co-simulation (COSISIM); Experimental variogram; Conditioning to hard and soft data; Multiple-point algorithms: single normal equation simulation (SNESIM) and direct sampling (DS); Training image; Integration of seismic data: cascaded workflow and simultaneous workflow.

Unit 5: *Seismic modelling* ***(5 hours)***
Synthetic seismogram from well log data; Normal incidence 2D seismic time sections: effect of frequency and depth; Born-filtered seismic images: impact of acquisition geometry and frequency; Surface seismic and cross-well seismic imaging.

References:

1) Avseth, P., Mukerji, T. and Mavko, G. (2005). *Quantitative Seismic Interpretation*. Cambridge University Press.
2) Mavko, G., Mukerji, T. and Dvorkin, J. (2009). *The Rock Physics Handbook*. Cambridge University Press.
3) Saxena, V., Krief, M. and Adam, L. (2018). *Handbook of Borehole Acoustics and Rock Physics for Reservoir Characterization*. Elsevier.
4) Caers, J. (2011). Modelling *Uncertainty in the Earth Sciences*. Wiley.
5) Remy, N., Boucher, A. and Wu, J. (2009). *Applied Geostatistics with SGeMS*. Cambridge University Press.
6) Mariethoz, G. and Caers, J. (2015). *Multiple-Point Geostatistics: Stochastic Modeling with Training Images*. Wiley.
7) Doyen, P. (2007). *Seismic Reservoir Characterization: An Earth Modelling Perspective*. EAGE.
8) Dubrule, O. (2003). *Geostatistics for Seismic Data Integration in Earth Models*. SEG. Caers, J. (2005). *Petroleum Geostatistics*. SPE.
9) Deutsch, C.V. (2002). *Geostatistical Reservoir Modeling*. Oxford University Press.
10) Goovaerts, P. (1997). *Geostatistics for Natural Resources Evaluation*. Oxford University Press.
11) Liner, C. (2004). *Elements of 3-D Seismology*. Pennwell Pub.
12) Biondi, B. (2006). *3D Seismic Imaging*. SEG.
13) Sen, M.K. (2006). *Seismic Inversion*. SPE.

AGP-401-P: Practical: Geophysical Tools III: MT & GPR Methods

L	Cr	IS	ES	T
2	1	20	30	50

AGP-402-P: Practical: Geophysical Tools IV: Gravity & Magnetic Methods

L	Cr	IS	ES	T
2	1	20	30	50

AGP-403-P: Practical: Geophysical Tools V: Well Logging

L	Cr	IS	ES	T
2	1	20	30	50

AGP-404-P: Practical: Reservoir Geophysics

L	Cr	IS	ES	T
2	1	20	30	50

AGP-4D-1: Marine Geophysics

L	Cr	IS	ES	T
4	4	40	60	100

AGP-4D-2: Geothermics & Geodynamics

L	Cr	IS	ES	T
4	4	40	60	100

AGP-4G-1: Environmental Geophysics

L	Cr	IS	ES	T
4	4	40	60	100

Semester V

AGP-501: Seismic Data Interpretation & Basin Analysis

L	Cr	IS	ES	T
3	3	40	60	100

Unit 1: *A brief review on mapping reflecting horizons* ***(4 hours)***
Picking/grading of reflections; Checking of loop closures of isochronal maps; Study of diffraction; Delineation of faults; Identification of multiples, reverberations; Identification of unconformity; Study of migrated and unmigrated sections; Preparation of isochronal /structural maps; Preparation of isopach maps.

Unit 2: *Seismic facies, Sequence analysis and modelling* ***(8 hours)***
Types of reflection characteristics; Different concepts of marine onlap; Identification of stratigraphic features like sand bodies, reefs, wedge outs etc.; Geologic sea-level change model; Reflections as constant time indicators; Picking seismic sequences, Picking of Unconformities to separate seismic sequences, Mapping seismic sequences on three dimensions; The modelling concept, The Convolutional model, Forward modelling: synthetic seismogram manufacture; Inverse Modeling: Seismic Log manufacture; Tie-up of seismic horizons with well data

Unit 3: *Seismic attribute analysis and hydrocarbon indicators* ***(4 hours)***
Amplitude is an important discriminant; Velocity as a diagnostic; Measurement of velocity; Resolution; Fresnel zone effects; Phase, frequency and polarity; Prediction of sand shale ratio, Determination of porosity; Detection of abnormal pressure.

Unit 4: *Basins and the sedimentary basin-fill* ***(8 hours)***
Basins due to lithospheric stretching; Basins due to flexure; Effects of mantle dynamics; basins associated with strike-slip deformation; The sediment routing system; Basin stratigraphy; basin subsidence and its thermal history.

Unit 5: *Application of* Basin *Analysis to Petroleum Play Assessment* ***(6 hours)***
The petroleum system and play concept; The petroleum charge system; The reservoir; The regional top seal; The trap; Basin classification, Habitats of major petroliferous belts and their relationship with plate tectonics, Exploration strategies.

References:

1. Allen, P.A., Allen, J.R., 2005. Basin Analysis – Principles and Applications, 2nd Edition, Blackwell.
2. Anstey, N.A, Seismic Interpretation, The Physical Aspects, International Human Resources Development Corporation, Boston, 1977.
3. Anstey, N.A., Seismic Exploration for Sandstone Reservoirs, IHRDC, Boston, 1980
4. Coffeen, J.A., Interpreting Seismic Data, Penn Well, 1984.
5. Dobrin, M.B. and Savit, C.H., Introduction to Geophysical Prospecting, Fourth Edition, McGraw-Hill, 1988.
6. Levorsen, A.I., Geology of Petroleum, CBS, Delhi, First Indian Edition, 1985.
7. Selley, R.C., Ancient Sedimentary Environments, Chapman and Well, London, 1978.
8. Sheriff, R.E., 1982. Seismic Stratigraphy, EBP Educational Reprint, Dehradun, First Indian Reprint.
9. Sheriff, R.E. and Geldart, L., 1983.Exploration Sedimentology Volume 2, Data Processing and interpretation, Cambridge University Press.
10. Sheriff, R.E., 2002.Encyclopedic Dictionary of Applied Geophysics, SEG Publications.
11. Visher, G.S., Exploration Stratigraphy, Penn Well, 1984.

AGP-502: Formation Evaluation

L	Cr	IS	ES	T
3	3	40	60	100

Unit 1: *Introduction to Formation Evaluation* ***(10 hours)***
Objectives, Archie's equation and essential calculations like water saturation (S_w) at different depths; determining formation water resistivity (R_w) by the SP method; "Quick-Look" methods in log analysis; cross plots and overlays: SP vs Rxo/Rt, Ro vs Rt, neutron density, sonic density etc.

Unit 2: *Porosity and Mineralogy*
Objectives; Cross-Plot Porosity and Lithology; Cross-Plot Gas effect; Cross-Plot Shale effect; Complex reservoir mineralogy [Lithology identification using M-N plots and MID plots for three mineral models]; Clastic Sedimentary Rocks; Carbonate Sedimentary Rocks; Mineral Identification Plots

Unit 3: *Clean formation evaluation*
Objectives; Standard approach for calculating Sw; Selecting appropriate logs for Exploratory, Development and Infill wells; Log Quality Assessment; Potential water-bearing zones and calculations; potential hydrocarbon-bearing zones and calculations; Decisions on productive capability; Moveable Hydrocarbon Index (MHI); Log-derived permeability [Wyllie and Rose (1950) Method, Coates and Dumanoir (1973) method]; Calculation of reserves.

Unit 4: *Shaly sand theory and applications*
Objectives; The nature of clay minerals and shale; Modes of occurrence of clay minerals; Assumptions involved in shaly sand analysis; Bound water in shaly sands; Log responses in presence of clay minerals; Procedures of shaly sand analysis [Determining the volume of shale (Vsh), effective porosity (Φe), effective water saturation (Swe) using Simandoux and Fertl, Dispersed clay and Dual Water Methods] and selection criteria of the appropriate method.

Unit 5: *Advanced logging tools associated with Formation Evaluation* ***(8 hours)***
FMI (Full-bore-formation Micro-Imager), CHFR (Cased Hole Formation Resistivity Tool), CAST (Circumferential Acoustic Scanning Tool), DSI (Dipole Sonic Imager), IPLT (Integrated Porosity Lithology Tool), CMR (Combinable Nuclear Magnetic Resonance Tool); Families of PEX (Platform Express Tools) & LWD (Logging While Drilling Tools) etc.

References:

1. "Basic Log Interpretation" HLS Asia Limited, 2007.
2. Bassiouni, Zaki, Theory, Measurement, and Interpretation of Well Logs, SPE Textbook Series Vol.4, 1994
3. Brock James, Applied Open-Hole Log Analysis, Gulf Publishing Company, 1986
4. Dewan, J. T., Essentials of Modern Open-hole Log Interpretation, PennWell Books, 1983.
5. "Basic Petroleum Geology And Log Analysis" Halliburton, 2001.
6. Ellis, D.V., Singer, J.M., 2008. Well Logging for Earth Scientists, 2nd Edition, Springer.
7. Rider, Malcolm, The Geological Interpretation of Well Logs, 2nd Edition, Rider-French Consulting Ltd, Scotland, 2002.
8. Schlumberger, Log interpretation principles/ Applications, 1999. Schlumberger Educational Services.
9. Serra, O., 1984. Fundamentals of well-log interpretation (1. The acquisition of logging data), Elsevier.
10. Serra, O.,1986. Fundamentals of well-log interpretation (2. The interpretation of logging data), Elsevier.

AGP-503: Sequence Stratigraphy

L	Cr	IS	ES	T
3	3	40	60	100

Unit 1: *Sequence Stratigraphy-An introduction* ***(3 hours)***
Historical development of sequence stratigraphy; Sequence models; Sequence stratigraphic approach – terminology, the concept of scale, Sequence Stratigraphy versus Lithostratigraphy and Allostratigraphy

Unit 2: *Fundamental concepts of sequence stratigraphy* ***(5 hours)***
Basin Controls and Processes involving sediment accommodation, sediment supply, effects of basin physiography, normal and forced regression; Definition of a sequence; Role of Tectonics in Sequence Architecture; Formation of Sequence and System Tracts [Lowstand Systems Tract (LST), Transgressive Systems Tract (TST), Highstand Systems Tract (HST)]; Cycles vs. Sequences; Sequences vs. Parasequences; Position and Timing of the Sequence Boundary; Sequence Hierarchies.

Unit 3: *Key surfaces, facies and systems tracts* ***(6 hours)***
Attributes of Sequence Boundary on the alluvial environment and the marine environment (Sequence boundaries on the shelf, slope and in the basin); Attributes of Maximum Flooding Surface on the alluvial environment, coastal and Shelf environment; Attributes of Transgressive Surface; Facies associated with Lowstand Systems Tract on alluvial deposits, Shoreface and Shelf Deposits, Deep-water Slope and Basin Deposits; Facies associated with Transgressive Systems Tract in the coastal settings with variable wave energy and tidal energy.

Unit 4: *Methods of Sequence Stratigraphic Analysis* ***(8 hours)***
Sequence Stratigraphic analysis based on Outcrops and Logs; identification of different surfaces, systems tracts, para-sequences, incised valley deposits for siliciclastic environments, sequence boundaries; Steps in the sequence stratigraphic analysis of the seismic sections; Tectonics and the seismic sequence stratigraphy.

Unit 5: *Sequence Models* ***(8hours)***
Types of stratigraphic sequences; Sequences in fluvial systems; Sequences in coastal to shallow-water clastic systems; Sequences in deep-water clastic systems; Sequences in Carbonate systems

References:

1. Catuneanu Octavian, 2006. Principles of Sequence Stratigraphy, Elsevier.
2. Loucks, R.G., Sarg, J.F. (Edited), 1993. Carbonate Sequence Stratigraphy-Recent Developments and Applications, AAPG Memoir 57.
3. Miall, A.D., 2000. Principles of Sedimentary Basin Analysis, Springer.
4. Posamentier, H.W., Allen, G.P., 1999. Siliciclastic Sequence Stratigraphy – Concepts and Applications, *SEPM (Society for Sedimentary Geology) Robert W Dalryrnple, Editor of Special Publications Concepts in Sedimentology and Paleontology No. 7*
5. Posamentier, H.W., Summerhayes, C.P., Haq, B.U., Allen, G.P. (Edited), 1993. Sequence Stratigraphy and Facies Associations, The International Association of Sedimentologists, Special Publication Number 18, Blackwell.
6. Williams, G.D., Dobb, A. (Edited), 1993. Tectonics and Seismic Sequence Stratigraphy, The Geological Society, London, Special Publication No. 71.

AGP-504: Simulation modelling in Environmental Science

L	Cr	IS	ES	T
3	3	40	60	100

Unit 1: *Introduction to simulation modelling*
Definition of a model; goals of modelling; general uses of modelling; brief review of statistics; steps to modelling; types of models; examples.

Unit 2: *Basics of R*
Introduction to R: vectors; operations on vectors; loops; data structures. Functions: applying functions to matrices, data frames and lists. Plotting: line plots, scatterplots, histograms, boxplots and bar plots.

Unit 3: *Model calibration and selection*
Definition of model performance; optimizing model performance; model complexity vs. model performance; model assessment; prediction vs. interpretation.

Unit 4: *Sensitivity analysis (SA)*
Goals of SA; properties of an ideal SA method; steps for SA; simple screening; Morris' method; variance-based SA measures.

Unit 5: *Model evaluation and predictions*
Finding data to evaluate a model; metrics of model performance based on data; comparing models to each other; estimating uncertainty in model predictions; reducing uncertainty with multi-model approaches.

References:

1. Saltelli, A., Chan, K. and Scott, E.M. (2000). Sensitivity Analysis. Wiley.
2. Oreskes, N., Shraderfrechette, K. and Belitz, K. (1994). Verification, validation, and confirmation of numerical models in the Earth sciences. Science, 263, 641–646.
3. Pebesma, E., Nüst, D. and Bivand, R. (2012). The R software environment in reproducible geoscientific research. Eos, Transactions American Geophysical Union, 93:163-163.
4. Schewe, J. and Levermann, A. (2012). A statistically predictive model for future monsoon failure in India. Environmental Research Letters, 7:044023.

AGP-501-P: Practical: Formation Evaluation

L	Cr	IS	ES	T
2	1	20	30	50

AGP-502-P: Practical: Seismic Data Interpretation & Basin Analysis

L	Cr	IS	ES	T
2	1	20	30	50

AGP-503-P: Practical: Sequence Stratigraphy

L	Cr	IS	ES	T
2	1	20	30	50

AGP-504-P: Practical: Simulation modelling in Environmental Science

L	Cr	IS	ES	T
2	1	20	30	50

AGP-5D-1: Advanced Seismology

L	Cr	IS	ES	T
4	4	40	60	100

AGP-5D-2: **Machine Learning and Artificial Intelligence for Geophysical Applications**

L	Cr	IS	ES	T
4	4	40	60	100

Unit 1: *Introduction*
Basic concepts, Supervised learning, Unsupervised learning, Reinforcement learning, Parametric and non-parametric methods, Bias-Variance tradeoff.

Unit 2: *Supervised Learning: Regression*
Linear regression, Variable selection, Regularization, Ridge regression, Lasso, Elastic net, Regression Trees, Bagging, Boosting, Random forests, Support vector machines, Cross-validation, Bootstrapping, Principal Components Regression, Partial Least Squares Regression, Basis functions, Splines, Generalized Additive Models.

Unit 3: *Supervised Learning: Classification*
Bayes classifier, k nearest neighbours, Logistic regression, Linear discriminant analysis, Quadratic discriminant analysis, Perceptron, Artificial neural networks.

Unit 4: *Unsupervised Learning*
Clustering, K-means clustering, Hierarchical clustering, Dimensionality reduction, Multidimensional scaling, Principal component analysis, Kernel methods.

Unit 5: *Applications*
Applications of machine learning algorithms in petroleum reservoir characterization, in decision-making related to the geosciences, and in value of information analysis for subsurface applications.

Suggested Books:

1) James, G., Witten, D., Hastie T. and Tibshirani, R. (2013). *An Introduction to Statistical Learning: with Application in R*. Springer.
2) Hastie, T., Tibshirani, R. and Friedman, J. (2009). *The Elements of Statistical Learning*. Springer.
3) Bishop, C. (2006). *Pattern Recognition and Machine Learning*. Springer.
4) Goodfellow, I., Bengio, Y. and Courville, A. (2016). *Deep Learning*. The MIT Press.
5) Eidsvik, J., Mukerji, T. and Bhattacharjya, D. (2015). *Value of Information in the Earth Sciences*. Cambridge University Press.

AGP-5A-1: Research Methodology & Science Writing

L	Cr	IS	ES	T
2	2	20	30	50

AGP-5A-2: Industrial Management

L	Cr	IS	ES	T
2	2	20	30	50

Semester VI

AGP-601-Dissertation/Project Work

Students are encouraged to take up problems having principally industrial implications or of more fundamental research concerns under the joint supervision of Dibrugarh University and external organizations.

Problems chosen can be purely geophysical / or any earth science-related issues having geophysical components / or, multi-disciplinary problems having broader societal concerns having geophysical components. Greater emphasis will be given to 'new lights' thrown on problems and enrichment of the current status of knowledge. Learning the use of new tools, software are encouraged but will be of secondary importance.

Irrespective of the problems selected, students are supposed to master seven essential components - (a) Literature survey to understand the current status of the problem; (b) Familiarity with the tools and the data required to address the problems; (c) Data analysis techniques and innovations in generating secondary data; (d) Data interpretation and data integration; (e) learning the art of discussion; (f) the art of drawing precise conclusions and (g) preparation of an error-free list of references.

The semester is divided into four slots: (i) Months 1&2 (January-February): Identification of the problem, literature survey, collection of maps, imageries etc. (ii) Month 3 (March): Data collection/ generation etc. (iii) Months 4 &5 (April-May): Data interpretation (iv) Month 6 (June): Writing the Report and preparation of at least one scientific paper for communication to scientific Journals.

In-semester Exams: 1st presentation (ppt/15 minutes each: 10 minutes for presentation + 5 minutes for discussion) in the 1st week of the month of March.

2nd presentation: (ppt /15 minutes each: 10 minutes for presentation + 5 minutes for discussion) in the 1st week of the month of May.

End-semester: Last week of the month of June.

Final presentation (ppt / 30 minutes each: 20 minutes for presentation + 10 minutes for viva-voce). Besides the presentation, candidates are supposed to submit:

(1) Two hard copies of the duly signed Dissertation Work

(2) Soft copies of the Dissertation in Word and pdf files

(3) Research communication (scientific paper in standard international format) in soft copies only in Word and pdf files (If considered to fulfil the required standard, the University reserves the right to publish the findings in the in-house journal with the 'first authorship' to the concerned candidate)

(4) Soft copy of the final ppt presentation.

Note: The schedule mentioned will have certain flexibility depending upon certain logistics controlled by the extra-institutional factors and weather conditions.

AGP-602-Seminar

At different stages of the progress of the Project Work, students will be delivering two (2) In-semester Seminars and one (1) End-semester Seminar.
Besides these, students will be encouraged to participate and deliver national and international seminars.

AGP-603-Comprehensive Viva Voce

Viva-voce by subject experts (subject to availability, external examiners preferably from the industries will be invited) will be having three layers of interactions- (i) Preliminary objective type (units, definitions scientific terms, simple formula etc.), (ii) Conceptual (physical significance, applications, advantages, disadvantages of different principles, tools etc.), (iii) Critical thinking (New problems, hypothetical situations etc.). During viva-voce, the candidates can also be offered pen and paper to work out smaller problems involving certain conceptual/critical issues.

AGP-604-Grand Comprehensive Test

Covering some of the key courses from all the previous semesters (I - V) a composite written test will be conducted which will be constituted of 50% objective (Choice-based) and 50% subjective questions. Subjective questions will be of two types – short (about 50 words) and moderately long (about 200 words)