COURSE OVERVIEW DE0124
Velocities
(E-Learning Module)

Course Title
Velocities (E-Learning Module)

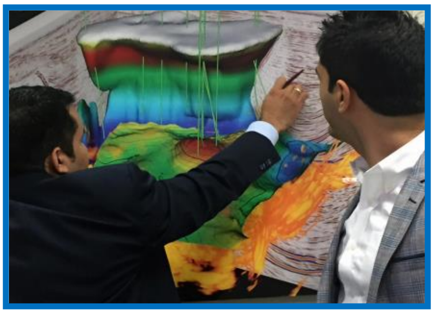
Course Reference
DE0124

Course Format & Compatibility
SCORM 1.2. Compatible with IE11, MS-Edge, Google Chrome, Windows, Linux, Unix, Android, IOS, iPadOS, macOS, iPhone, iPad & HarmonyOS (Huawei)

Course Duration
30 online contact hours
(3.0 CEUs/30 PDHs)

3.0 CEUs (30 PDHs) AWARD

Course Description



This E-Learning course is designed to provide participants with a detailed and up-to-date overview of velocities. It covers the seismic velocities, principles, definitions, analysis and the basic concept of seismic exploration; the medium effects on waves, geometrical spreading, absorption and reflection/refraction; the Snell's law, reflection coefficients, magnitude, seismic events, seismic wavelet and seismic resolution; and the model of a sedimentary rock, common calculation methods, seismic data acquisition and sonic well logging.

Further, the course will also discuss the seismic sources, seismic recording systems, sources of noise, reference diagram for land static corrections and source of various components of static correction; the normal moveout equation and the concept of constant velocity stack as an aid to stacking velocity estimation; the velocity spectra and the options in the promax velocity analysis routine; the use of promax routine velocity viewer and editor; the common problem with stacking including the example of the data/velocity interleave display using landmark's seiscube program; and the progressive mute analysis and methods of velocity-analysis.

During this course, participants will learn the factors controlling analysis locations and choosing locations on a stacked section; the methods of velocity picking and interpolation, well velocity measurements, schematic cross section, corrections and sonic log integration; the interval velocity functions, well ties, instantaneous velocity, hybrid functions, average velocity function and geological effects; and the calibration, 3-parameter analysis, horizon velocity analysis, editing, filtering, smoothing, averaging and normalization.

Course Objectives

After completing the course, the employee will be able to:-

- Apply and gain a comprehensive knowledge on velocities
- Discuss seismic velocities, principles, definitions, analysis and the basic concept of seismic exploration
- Describe the medium effects on waves, geometrical spreading, absorption and reflection/refraction
- Explain Snell's law, reflection coefficients, magnitude, seismic events, seismic wavelet and seismic resolution
- Illustrate the model of a sedimentary rock, common calculation methods, seismic data acquisition and sonic well logging
- Recognize seismic sources, seismic recording systems, sources of noise, reference diagram for land static corrections and source of various components of static correction
- Examine the normal moveout equation and discuss the concept of constant velocity stack as an aid to stacking velocity estimation
- Demonstrate velocity spectra and identify the options in the promax velocity analysis routine
- Use promax routine velocity viewer and editor and recognize the common problem with stacking including the example of the data/velocity interleave display using landmark's seiscube program
- Apply progressive mute analysis and methods of velocity-analysis as well as identify the factors controlling analysis locations and choose locations on a stacked section
- Carryout methods of velocity picking and interpolation, well velocity measurements, schematic cross section, corrections and sonic log integration
- Discuss interval velocity functions, well ties, instantaneous velocity, hybrid functions, average velocity function and geological effects
- Employ calibration, 3 parameter analysis, horizon velocity analysis, editing, filtering, smoothing, averaging and normalization

Who Should Attend

This course provides an overview of all significant aspects and considerations of velocities for geoscientists and engineers, especially seismic interpreters, and anyone who needs to understand the basic theory and procedures for creating velocity models and converting seismic data from time to depth.

Course Certificate(s)
Internationally recognized certificates will be issued to all participants of the course.

Certificate Accreditations
Certificates are accredited by the following international accreditation organizations:-

- USA International Association for Continuing Education and Training (IACET)

  Haward Technology is an Authorized Training Provider by the International Association for Continuing Education and Training (IACET), 2201 Cooperative Way, Suite 600, Herndon, VA 20171, USA. In obtaining this authority, Haward Technology has demonstrated that it complies with the **ANSI/IACET 1-2013 Standard** which is widely recognized as the standard of good practice internationally. As a result of our Authorized Provider membership status, Haward Technology is authorized to offer IACET CEUs for its programs that qualify under the **ANSI/IACET 1-2013 Standard**.

  Haward Technology's courses meet the professional certification and continuing education requirements for participants seeking **Continuing Education Units** (CEUs) in accordance with the rules & regulations of the International Association for Continuing Education & Training (IACET). IACET is an international authority that evaluates programs according to strict, research-based criteria and guidelines. The CEU is an internationally accepted uniform unit of measurement in qualified courses of continuing education.

  Haward Technology Middle East will award **3.0 CEUs** (Continuing Education Units) or **30 PDHs** (Professional Development Hours) for participants who completed the total tuition hours of this program. One CEU is equivalent to ten Professional Development Hours (PDHs) or ten contact hours of the participation in and completion of Haward Technology programs. A permanent record of a participant's involvement and awarding of CEU will be maintained by Haward Technology. Haward Technology will provide a copy of the participant's CEU and PDH Transcript of Records upon request.

- British Accreditation Council (BAC)

  Haward Technology is accredited by the **British Accreditation Council** for **Independent Further and Higher Education** as an **International Centre**. BAC is the British accrediting body responsible for setting standards within independent further and higher education sector in the UK and overseas. As a BAC-accredited international centre, Haward Technology meets all of the international higher education criteria and standards set by BAC.

Course Fee
As per proposal

Training Methodology
This Trainee-centered course includes the following training methodologies:-

- Talking presentation Slides (ppt with audio)
- Simulation & Animation
- Exercises
- Videos
- Case Studies
- Gamification (learning through games)
- Quizzes, Pre-test & Post-test

Every section/module of the course ends up with a Quiz which must be passed by the trainee in order to move to the next section/module. A Post-test at the end of the course must be passed in order to get the online accredited certificate.

Course Contents

- Seismic Velocities
- Principles
- Velocity Definitions
- Velocity Analysis
- Principles
- Basic Concept of Seismic Exploration
- Seismic Waves P-Wave
- Seismic Waves S-Wave
- Seismic Wave Surface Wave
- Medium Effects on Waves
- Geometrical Spreading
- Absorption
- Geometrical Spreading versus Absorption
- Reflection/Refraction
- Snell's Law
- Diffraction
- Reflection Coefficients
- Magnitude
- Time-Distance (T-X) Curves

- Single Horizontal Layer
- Single Dipping Layer
- Multiple Layers
- Seismic Events
- Primary Reflections
- Non-Primary Events
- Direct Waves
- Head Waves (Refractions)
- Diffractions
- Multiples
- Ground Roll
- The Seismic Wavelet
- Seismic Resolution
- Vertical
- Velocity Porosity Relations
- Seismic Velocity
- Model of a Sedimentary Rock
- Porosity Relations
- Porosity Relation with Density and Velocity
- Types
- Common Calculation Methods
- Velocity Determination - $T-\Delta T_{NMO}$ method
- Uses of Velocity Data
- Seismic Data Acquisition
- Land Equipment
- Marine Equipment
- Recording
- 2-D Field Methods
- The CMP Method
- Spreads
- Split Spread
- End-On Spread
- Arrays

- T-X for a Single, Horizontal, Homogeneous Layer
- Time-Distance (T-X) Curves
- Multiple Layers
- Single Horizontal Layer
- Single Dipping Layer
- Multiple Layers
- Comparing Velocities
- Estimation of V_{NMO}
- Check-Shot Survey
- Vertical Seismic Profiling (VSP)
- Concept
- Example
- Sonic Well Logging
- Tool
- Data Example
- Non-primary Linear Events
- Diffraction
- Seismic Events - Non-Primary Events
- The Seismic Wavelet
- Seismic Events - Primary Reflections
- Seismic Data Acquisition - Land Equipment
- 2-D Field Methods - The CMP Method
- Velocity Determination - Hyperbolic-Fit Method
- Relation Between True T-X curve and RMS and Stacking Velocities
- Velocity Determination - T-DT_{NMO} Method
- Gathers after Detailed Velocity Analysis
- CDP gather before and after SRME
- Velocity Analysis
- Equipment Overview
- Seismic Sources
- Small Shear-Wave Source for Near-Surface Site Investigations.
- Vibrator Had Competition…this is CGG's "Marthor" Hammer
- Early Version of Assisted Weight Drop Seismic Source.

- Weight-drop seismic source being used in the desert where drilling is difficult for explosives and Vibroseis can be ineffective.
- The most common, buried point source explosive for seismic.
- "Marthor" wasn't the only competition…here's another CGG idea
- P-wave Vibroseis vibrator buggy.
- P-wave Vibroseis vibrators forming a source array.
- Series of seismic Vibroseis vibrators executing a source array.
- P-wave vibrator with baseplate down and executing sweep.
- Conoco shear-wave vibrator mounted on a Crane carrier
- Vibrator worked well in clay soils; not a friend of OK bridges
- Close-up of the baseplate of a S-wave Vibroseis vibrator.
- Divots left in the ground from the S-wave vibrator.
- Schematic showing the forcing functions of the P-wave and S-wave Vibroseis seismic sources.
- Geophones
- Vertical (Z-component) geophone that is part of an array.
- Picture comparing conventional vertical geophone (left) with two-component geophone for PP and PS acquisition.
- Schematic showing the operation of the geophone
- Seismic recording Systems
- Sources of Noise
- Interpretation: reading First Arrivals
- Practice Picking First Arrivals
- Polarity standards det by the Society of Exploration geophysicists
- CDP gather
- Example processing flow for seismic data
- Overview statement about seismic reflection statics.
- Reference diagram for land static corrections
- Source of various components of static correction.
- Stack of line without the application of statics.
- Example where ProMax routine made a static solution in a tough data area that resulted in cycle skipping
- Another routine is used to interpret and repair damage.
- Typical ProMax flow for velocity analysis.

- Examining the normal moveout equation, it is possible to analyze NMO velocities by plotting reflections in T^2 X^2 space
- Concept of Constant Velocity Stack as an aid to stacking velocity estimation.
- One method to determine stacking velocity is to use a Constant Velocity Stack (CVS) for several CDP gathers
- Same CVS panel of traces as before switching to variable density color for the traces to utilize dynamic range
- Same as previous color panels with velocity range now halved to better pick correct velocities
- Another term for Normal Moveout Equation.
- Options in the ProMax Velocity Analysis Routine.
- Demonstration of the velocity spectra
- Options in the ProMax Velocity Analysis Routine.
- CDP gather with NMO applied (center) surrounded by panels having progressively lower velocity (left) or higher velocity.
- Options in the ProMax Velocity Analysis Routine.
- From left to right are panels for Semblance, Gather, Dynamic Stack, Flip Stacks, and Velocity Function Stack.
- The ProMax routine 'Velocity Analysis' has it all – from left to right: velocity spectra, interactive cursor with CDP gather, dynamic stack, and a variation on CVS
- The Semblance Panel shows the semblance plot, the picked velocity function, guide functions, and the interval velocity computed from the picked function.
- Dix equation converts stacking velocities to interval velocities.
- However, you get RMS velocities, one can continue to calculate interval velocities, interval thicknesses, and average velocities.
- Remaining three panels in Velocity Analysis routine.
- Use of ProMax routine Velocity Viewer and Editor
- A common problem with stacking is residual NMO on the CDP gathers resulting from imperfect velocity specification.
- Example of the data/velocity Interleave Display using Landmark's SeisCube program.
- Progressive Mute Analysis
- Prestack CDP gather with a horizon plotted along an event that is not perfectly flattened by NMO; other causes might be statics, noise, and/or lithology that is affecting the phase.
- Velocity analysis

- Difefrence between CMP and CDP
- Methods of Velocity-analysis
- X2-t2 – analysis
- Aim of velocity analysis
- CMP gathers with strong multiples
- CMP stack using former gathers
- Factors affecting velocity estimates
- Reflection coefficients
- Velocity determination
- Moveout
- Compression Wave Velocity
- Velocities
- Why is velocity important?
- Is it the same velocity in all cases?
- So where do we start?
- Agenda
- Average Velocity
- Interval Velocity
- RMS Velocity
- Interval Velocity of layer using the RMS velocities
- Velocity Definitions Continued
- Apparent Velocity
- NMO (Normal Moveout) Velocity
- NMO Application
- Residual NMO
- Velocity; interval, nmo, stacking, rms, average
- NMO Stretch
- NMO Stretch - An Example
- Stretch – Example
- Mute Definitions
- Stacking velocity Increases with dip
- Velocity Analysis
- Velocity Analysis Tools

- Velocity Picking ; Omega 2 = INVA   Interactive Velocity Analysis
- Semblance Analysis
- Velocity Analysis; MVFS; Multi Velocity Function Stacks
- Multi Velocity Function Stacks
- Constant Velocity Stack
- Constant Velocity Gathers
- Some Velocity Analysis Tools (Summary)
- Multiples
- Water Bottom Multiples
- Peg Leg Multiples
- Factors controlling Analysis Locations
- Choosing Locations on a Stacked Section
- Picked velocity file
- Methods of Velocity Picking and Interpolation
- Velocity Inversions
- Q.C. of velocity field
- IVP iso-velocity display
- Seismic Velocities& Depth Conversion
- Introduction
- Objective of course
- Travel time inversion
- Technology usage
- Depth Conversion
- New Paradigm
- Basic concepts
- Macrovelocity
- The Macrovelocity Model
- Structural sources
- Well velocities
- Seismic Velocities
- Structural detail
- Surfaces to model
- The Macrovelocity Model

- Structural Complexity
- Velocity for T-Z Conversion
- Velocity Models
- Velocity Definition 1
- Average velocity V_A
- Average Interval Velocity V_1
- Average Velocity V_A
- Instantaneous Velocity V_i
- Pseudo Velocity (Apparent, effective)
- RMS Velocity
- Summary
- Exercise 1
- Exercise 2
- Summary
- Well Velocity 1
- Well Velocity Measurements
- Checkshot
- Schematic cross section
- Velocities
- Source
- Near Surface
- Ray paths – Zero Offset
- Well Velocity Curves
- VSP
- Vertical Seismic Profile
- Geometry
- Records
- Velocities
- Walk Above VSP
- Corrections
- Sonic
- Sonic Log
- Tool

- BHC and LSS
- BHC Log
- BHC Problems
- Sonic Log
- Long Spaced Sonic Log
- Full Waveform Sonic Log
- Shear - Shear wave Logs
- Velocity Log
- Sonic Log Integration
- Discrepancies
- Absorption and Dispersion
- Sonic log and Checkshots
- Drift Curve
- Dispersion
- Calibration
- Calibrated Sonic/Velocity Log
- Pseudo Velocity
- Datum
- Composite Reflections
- Depth
- Travel Time Error
- Travel Time Error – AVO
- Travel Time Error – Position
- Travel Time Error – Stack
- Summary
- Exercise 1
- Checkshot/VSP Models
- Interval Velocity
- Constant
- Exercise
- Interval Velocity Functions
- Well ties
- Velocity as a Function

- Instantaneous Velocity
- Evjen's Function
- The Error
- Exercise
- Hybrid Functions
- Instantaneous Velocity Functions
- Instantaneous Slowness Functions
- Summary
- Average Velocity
- Interval Velocity
- Instantaneous Velocity
- Exercise
- Selecting the best Function
- Functions
- Extrapolation
- Summary
- Constant Average Velocity
- Average Velocity Function
- Constant Interval Velocities
- Interval Velocity as a Function
- Instantaneous Velocity as a Function
- Sonic/Velocity Log Models
- Velocity Models from Well Logs
- Integration
- Blocking
- Interval Velocity
- Time Average
- Wylie's Time-Average Equation
- Depth Average
- Exercise
- Functions
- Instantaneous Velocity
- Slotnick

- Faust
- Evjen
- Exercise
- Extrapolation
- Combining Logs
- Adding Seismic Velocities
- Geology
- Tectonic Inversion
- Diagenesis
- Rate of Deposition
- Lithology
- Overpressure
- Blocking
- Functions
- Geological Effects
- Exercise
- Velocity Definitions 2
- RMS Velocity
- Root Mean Square (RMS) Velocity V_{RMS}
- Heterogeneity Factor
- Moveout Velocity
- Moveout Equation
- Moveout $T^2 - X^2$ Plot
- Normal Moveout Velocity V_{NMO}
- Normal Moveout
- Multiple Layers
- Taylor Series
- (RMS) Interval Velocity
- Long Offset
- Stacking Velocity Analysis
- Stacking Velocity V_s
- Stacking Velocity in T^2-X^2 space
- Stacking Velocity for our Model

- CMP gathers
- Results
- Bias – B
- Interval Stacking Velocity V_{IS}
- Average Stacking Velocity V_{IS}
- Migration Velocity
- Refraction Velocity
- Summary
- Exercise
- Rays and Models
- Raytrace Modelling
- Seismic Velocity 1
- Refraction Analysis
- Basic Theory
- Picking
- More Theory
- Statics Software
- QC of picks
- Velocity gradients
- Modelling
- Model output
- Pitfalls
- Uphole Surveys
- Calibration
- Exercise
- Stacking Velocity
- Semblance Plot
- Constant Velocity Panels
- Exercise
- Dip and Stacking Velocity
- 3 Parameter Analysis
- Stacking Velocity with DMO
- Prestack DMO

- Prestack V(z) DMO
- Horizon Velocity Analysis
- Stacking Velocity Cube
- Interpolation
- Summary
- Stacking Velocity
- Error in Stacking Velocity
- Near Surface Structure
- Moveout
- Refraction Velocity
- Near Surface Low Velocities
- Statics
- Field Statics
- Stacking Velocity Distortion
- Field Statics 1
- Example Field Statics 1
- Residual Statics
- Without Statics
- With Statics
- Dip and structure
- Gradual lateral Changes
- Long Wavelength Static Anomaly
- After Statics
- Post Stack Statics
- Severe Evaluation
- Abrupt Lateral Changes
- Cross-line Dip
- Seismic Velocities
- Error in Stacking Velocity
- Picking
- Judgement
- Pick at 0.8 sec
- Pick at 0.9 sec

- Pick at 1.2 sec
- Sampling Increment
- Window
- Random Noise
- Coherent Noise
- Range of Offset
- Near Surface Picking
- Error in Stacking Velocity
- Bias
- Flat Layer Non-Hyperbolic Moveout
- Long Offset Data
- Error in Stacking Velocity
- Semblance & Coherency Algorithms
- Uncertainty in T_0
- Uncertainty
- Errors in Stacking Velocity
- Offset
- Speed
- Errors in Stacking Velocity
- Exercise
- Interval Velocity Model
- Exercise 1
- Dip Correction
- Bias Correction
- Method 1
- Method 2
- Method 3
- Method 4
- Interpolation
- Exercise 2
- Smooting
- Interval RMS Velocity
- Sensitivity

- Rule
- Field Statics
- Editing
- Noise
- Filtering
- Smoothing
- Averaging
- Spatial Averaging
- Surface Fitting
- Smoothing
- Normalization
- Work Flow
- The First Macrovelocity Model
- Stacking Value Matching
- Travel Time Inversion – Tomography
- Summary