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# Introduction to Coordinate Measuring Machines On-Site Seminar

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Today's Coordinate Measuring Machines (CMMs) offer unprecedented speed, accuracy, and flexibility for dimensional metrology, data collection, and geometric or statistical analysis. From the smallest job shops to the largest multinational corporations, CMMs have become essential tools for achieving quality. But the capabilities and limitations of CMMs vary tremendously from one machine to another.

*Introduction to Coordinate Measuring Machines* provides an overview of all aspects of selecting and using CMMs. Representative examples of all types of CMMs, from a wide variety of manufacturers, are discussed. The Seminar includes the latest information on manual and computer controlled machines at every level of sophistication. The content can be customized to include information on the specific machines that are of interest to your company.

*Introduction to Coordinate Measuring Machines* is oriented toward Managers, Supervisors, Operators, Engineers, and Quality Professionals. It consists of six instructional units and requires approximately eight hours for presentation. Participant materials include copies of selected illustrations and reprints of key Coordinate Measuring Machine articles and technical papers. Various presentation schedules are available to meet your requirements.

Call us to learn how to make better use of existing CMMs, how to understand their capabilities and limitations, and how to make better purchasing decisions on upgrades or new machines.

## Seminar Outline:

### Unit 1 - Elements of Modern CMMs

- Introduction
- Typical Coordinate Measuring Machine
- Probes and Probing Systems
  - Hard Probes
  - Electronic Probes
  - Noncontact Probes
- Super Structures
  - Fixed Horizontal Arm
  - Moving Horizontal Arm
  - Column
  - Cantilever
  - Fixed Bridge
  - Moving Bridge
  - L-Shaped Bridge
  - Gantry
  - 4th Axis
  - 5th Axis
- Measuring Systems
  - Glass Scales
  - Reflective Scales
  - Rack and Pinion/Rotary Encoders
  - Inductive Encoders
  - Magnetic Scales
  - Laser Interferometers
- Readout Systems
  - Analog Devices
  - Digital Readouts
- Computer Systems
  - Smart Readouts
  - Desktop Computers
  - Minicomputers
  - Mainframe Computers
- Software
  - Printout Only
  - 1 Dimensional Functions
  - 2 Dimensional Functions
  - 2 1/2 Dimensional Functions
  - Solid Geometric Functions
  - Curve Fitting
  - Plotting
  - Statistics
  - CAD/CAM/CIM

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## Unit 2 - Coordinate Measurement

- Coordinate Systems
  - Absolute Coordinate Space
  - Working Planes of the Machine
  - Workpiece Coordinate Systems
  - Problems With Angle Measurements
- 2 Dimensional Measurement
  - 2 Dimensional Measurement Assumptions
  - Hard Probe Methods
  - Smart Readouts and Hard Probes
  - Desktop Computers and Hard Probes
  - Summary of 2 Dimensional Measurement
- 2 1/2 Dimensional Measurement
  - Assumptions
  - Electronic Probes
  - Smart Readouts
  - Desktop Computers
  - Software Considerations
  - Summary of 2 1/2 Dimensional Measurement

## Unit 3 - Solid Geometric Measurement

- Geometric Elements
  - Point
  - Line
  - Circle
  - Plane
  - Ellipse
  - Sphere
  - Cylinder
  - Cone
- 3 Dimensional Coordinate Systems
  - Normal to a Plane
  - Axis of a Cylinder
  - Axis of a Cone
- Combinations of 2 Dimensional Elements
  - Distance Between Points
  - Distance Between Lines
  - Point of Symmetry
  - Intersection of Lines
  - Intersection of Line and Circle
  - Intersection of Circle and Circle
  - Patterns of Features
- Combinations of 3 Dimensional Elements
  - Intersection of 2 Planes
  - Intersection of 3 Planes
  - Intersection of Cylinder and Plane
  - Intersection of Cone and Plane
  - Intersection of Cylinder and Cylinder
  - Intersection of Cylinder and Cone
  - Intersection of Cone and Cone
  - Plane of Symmetry
- Summary of Solid Geometric Measurement

## Unit 4 - GDT and the CMM

- Interpretation of Drawings
  - Drawing Specifications and Systems
  - Translating Drawing Specifications to Workpiece Coordinates
  - Problems With Drawings
- General Principles of GDT
  - Limits of Size
  - RFS, MMC, and LMC
  - Virtual Condition
- Symbology
- Notes
- Geometric Tolerance Symbols
- Feature Control Frames
- Datum Referencing
  - Datum Features
  - Establishing Datums
  - Datum Targets
- Tolerances of Location
  - Positional Tolerancing
  - Feature Pattern Location
  - Projected Tolerance Zones
  - Noncircular Features
  - Coaxiality
  - Symmetry
- Form, Profile, Orientation, and Runout Tolerances
  - Form Tolerances
  - Profile Tolerances
  - Orientation Tolerances
  - Runout Tolerances
  - Free State Variation
- Summary

## Unit 5 - Human Factors and the CMM

- Measurement Strategy
  - Dependence on Capability of CMM
  - Importance in Achieving Accuracy
  - Importance is Saving Measurement Time
- Manual Machines
  - Operator Technique with Hard Probes
  - Operator Technique with Electronic Probes
  - Tips for Improved Accuracy in Measurement
- Driven Machines
  - Joystick Control Technique
  - Speed at Probe Contact
  - Forces Exerted on the Workpiece
- Probe Qualification

## Unit 6 - Measurement Uncertainty

- Individual contributors
  - Probing Systems
  - Super Structures
  - Measurement Systems
  - Readout Systems
  - Computer Systems
  - Software
  - Environment
  - Operator
- Accuracy Evaluation
  - B89
  - CMMA
  - Simple Artifact Tests
- Active Compensation
  - Mapping
- Summary

For more information on our complete range of products and services, please visit us on the web, call, or write...

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*Note: Innovations PLUS provides independent and unbiased information to Clients on all types of Dimensional Metrology Equipment and is not affiliated with any manufacturer of Coordinate Measuring Machines.*