B. MEASUREMENT

B1. Describe Measurement's Role in Manufacturing

B1.1. Match measurement activities to manufacturing process.

Performance Objective: Given a list of three different manufacturing processes, the student will be able to match different measurement activities used in each process.

Manufacturing processes:	Measurement Activities:		
	What?		How?
Designing Tooling Fabrication: Sand casting Machining Welding Sheet metal Forging Assembly	Space Weight Hardness: Rockwell Brindel Pressure: Liquid Air Torque	Time Heat Electricity Radioactivity Man-hours Costs	Instruments and procedures

B1.2. Select & use appropriate measurement techniques and instruments

Performance Objective: Given a technical drawing and a piece of wood stock, the student will be able to demonstrate the selection and use of the appropriate measurement tools and techniques to transfer the specification to the wood with a accuracy of $\pm$ 1/32 inch.

Instruments:	Techniques: (How and What is done?)
Rulers to 1/64″ Protractors Outside calipers Inside calipers Vernier calipers Micrometer calipers Combination Square Scales (weight) Torque wrench Barometers Thermometers Rockwell Brindel	Location by: linear distance polar coordinates rectangular coordinates radius or diameter From point to point From datum lines Given tolerances Triangulation Area Parts alignment Temperature and pressure Tolerances First part Frequency

B1.3. Describe measurement's role in manufacturing.

Performance Objective: The student will be able to identify six areas/things that can be measured in the manufacturing process.

Areas of Measurement Applications	
Technical communication Estimating Cost-effectiveness labor Statistical analysis Make/buy decisions Efficiency Waste/value added Rework	Specifications Conformance durability Reliability Safety Serviceability

B2. Identify Types of Measurement Used in Manufacturing

B2.1. Distinguish between direct and calculated measurements.

Performance Objective: The student will be able to identify three examples of direct measurements and three examples of calculated measurements and explain the difference.

Direct measurements	Calculated measurements
Height, width, and depth Angles Liquid volume Torque (read from tool) Temperature Pressure	Spatial volume Material costs Labor costs Overhead costs Statistical summaries Waste Value added Measurement conversions Fractions Linear Angles

B2.2. Compute calculated measurements.

Performance Objective: Given ten (10) practical application problems, the student will be able to correctly perform the required calculations for 90% of the problems.

Problem: Given a drawing of a simple deck, the student will be able to calculate the amount of lumber in board feet needed for construction.

Problem: Given the need to pour a concrete pad 8 by 10 feet by 3 inches deep, the student will be able to calculate the volume in cubic yards of concrete required.

B2.3. Demonstrate general measurement techniques.

Performance Objective: Given two rooms in the school facility, the student will be able to record, on a simple plan drawing, the dimensions of those rooms within 1/4″ (excluding molding) and calculate the amount of carpeting in square yards (12′ wide roll) necessary to cover the floors with the least amount of waste.

B2.4. Demonstrate semi-precision measurement techniques.

Performance Objective: Using a price list from a local lumber yard, the student will be able to design an 8 by 16 foot second-floor outside deck (with stairs) based on a cost effective use of standard wood dimensions and prepare a list of wood product materials and hardware.

B2.5. Demonstrate precision measurement techniques.

Performance Objective: Given one machined part, necessary precision measurement instruments, and the need to prepare a drawing for a second and mating part, the student will be able to generate and dimension the drawing of the second part to a tolerance of ±.030.

Precision Measuring Instruments		
Micrometers	Depth gauges	Universal bevel gauge
Inside micrometers	Vernier calipers	Universal bevel protractors
Ball micrometers	Vernier height gauge	Ohm-meter
Gear tool vernier	Dial calipers	Oscilloscope
	Electronic calipers	

B2.6. Justify the use of precision measurements in manufacturing.

Performance Objective: The student will be able to give reasons and identify situations where precision measurements are justified.

Situations and Reasons	
High tolerance parts	Expansion and contraction variances
Mating parts Precision assemblies	Precious materials - gold, etc.
Temperature and Pressure variances	Miniature and sub-miniature electronic components
Eliminate waste	

B3. Understand the importance of Calibrating Measurement Equipment.

B3.1. Explain calibration requirements of various precision instruments.

Performance Objective: Given two precision instruments, the student will be able to recognize precision instruments that require calibration, state the calibration requirements and give reasons for these requirements, and verify that the calibration of the instruments is not outdated and is within cycle.

B3.2. Illustrate Measurement Differences when taken with Calibrated and Non-Calibrated Instruments.

Performance Objective: Given a variety of measurement instruments of the same kind but from different manufacturers and two calibrated instruments, the student will be able to state and explain the differences between the measurements taken by calibrated and noncalibrated instruments.

B4. Select Proper Tools for Measurement

B4.1. Match Appropriate Measurement Tools with Various Types of Measurement Requirements.

Performance Objective: Given a description of three different jobs, the student will be able to identify what measurements are required and select the appropriate measurement tools.

B4.2. Demonstrate Proper Measurement Tool Usage.

Performance Objective: Given an object and the necessary measurement tools, the student will be able to correctly demonstrate how to use the tools to make necessary measurements to create a technical drawing.

B4.3. State Selection Criteria For Measurement Tools.

Performance Objective: The student will be able to identify three different tasks and state the criteria for selecting the appropriate measurement tools.

Examples: Machining, sheet metal, carpentry, electronics.

B5. Convert Units From One Measurement System to Another

B5.1. Convert Between USCS And Metric Measurement Systems.

Performance Objective: Given a drawing with USCS measurements and a copy of the same drawing with no dimensions, the student will be able to dimension the second drawing with metric equivalents.

B5.2. Convert Fractional Measurements To Decimal Measurements.

Performance Objective: Using just a pencil and paper, the student will be able to convert ten different fractional measurements to decimal measurements to the thousandth decimal place with 100% accuracy.

B5.3. Compute Within Measurement Systems.

Performance Objective: Working within the metric system, the student will be able to convert a list of different measurements to millimeters, to centimeters, to kilometers.

Performance Objective: Given a list of fractions, the student will be able to divide in two, double and triple each with 100% accuracy.

NOTE: Students should be able to perform calculations without the use of a calculator.

B6. List Characteristics of Measurement Tools

B6.1. Explain The Function Of Measurement Tools.

Performance Objective: The student will be able to list ten different functions of measurement tools used in daily life and in the workplace.

B6.2. Justify The Use Of Particular Measurement Tools Based On Tool Characteristics.

Performance Objective: Given a list of five different measurement tools, the student will be able to identify the unique characteristics of each tool and give examples of its use.

Rulers/scales Steel ruler -1/64” Architect scale Engineer’s scale Protractors Meters	Outside calipers Inside calipers Vernier calipers Micrometer calipers Scales (weight) Torque wrench

B7. Perform Measurements with General, and Precision Tools

B7.1. Perform Measurements.

Performance Objective: Given general and precision measurement instruments, the student will be able to demonstrate the correct use for taking measurements.

B7.2. Document Results Of Measurement Activities And Calculations.

Performance Objective: Given a part, and general and precision measurement instruments, the student will be able to clearly record at least ten measurements from the part and calculate area and volume with 95% accuracy when compared to a benchmark model.

B7.3. Interpret Results Of Measurements And Calculations.

Performance Objective: Given general and precision measurement tools, five production parts, and having recorded the measurements and related calculations, the student will be able to interpret the results in a problem-solving process to eliminate variance among parts.

B8. Describe Common Measuring Errors and Proper Measuring Practices

B8.1. List Steps Of Proper Measurement Procedures.

Performance Objective: Given an object to be measured, the student will be able to list the basic steps necessary to ensure the complete and accurate measurement of the object.

B8.2. Explain Rationale For Each Step.

Performance Objective: Given a list of the basic steps in the measurement process, the student will be able to state the reasons why each step is necessary.

B8.3. Identify Error Possibilities In Measurement Tool Selection.

Performance Objective: Given the need to select the proper measurement tools, the student will be able to state the rationale for tool selection and the appropriateness for the task.

B8.4. Identify Error Possibilities Within Measurement Procedures.

Performance Objective: Given the process of taking measurements, the student will be able to list the possible errors that may occur.

ERROR POSSIBILITIES	
Improper instrument used	Measurement locations
Mis-reading the instrument	Measurement calculations
Errors in calibrations	

B8.5. Identify Common Conversion Error Possibilities.

Performance Objective: The student will be able to identify possible errors when making conversions among fractions, decimals and metrics measurement systems.

B9. DESCRIBE MEASURING SYSTEMS

B9.1. Define Measurement

Performance Objective: The student will be able to define measurement as it applies to the workplace.

B9.2. Distinguish Between General And Precision Measurements.

Performance Objective: The student will be able to state the difference between and give examples of general versus precision measurements.

B9.3. Distinguish between USCS and Metric Measurement Systems.

Performance Objective: The student will be able to state the uniqueness of the USCS and the metric measurement systems.

B9.4. Compare And Contrast Different Measuring Systems And Techniques.

Performance Objective: Given a common object, the student will be able to provide a comparative demonstration of different measurement techniques.

Performance Objective: Given a common object, the student will be able to provide a comparative demonstration of different measurement systems.

B9.5. Select Measuring System And Procedures Based On System Characteristics.

Performance Objective: Given three different task/problem statements, the student will be able to select the best measurement process for the task and give reasons for their selection based on the characteristics of the systems.