The 4 Pillars of Manufacturing Knowledge

1. Materials and Manufacturing Processes
   - Engineering Sciences
   - Materials Manufacturing Processes

2. Product, Tooling and Assembly Engineering
   - Product Design
   - Process Design
   - Equipment/Tool Design

3. Manufacturing Systems and Operations
   - Product System Design
   - Automated Systems and Control

4. Manufacturing Competitiveness
   - Quality
   - Continuous Improvement
   - Manufacturing Management

Foundation

Mathematics and Science
- Analytic Geometry, Algebra, Biological Sciences, Calculus, Chemistry, Physics, Probability/Statistics, Trigonometry

Engineering Sciences
- Statics and Dynamics
- Mechanics of Materials
- Fluid Mechanics
- Thermodynamics/Heat Transfer
- Electrical Circuits/Electronic/Instrumentation/ Material Science

Engineering Materials
- Metals
- Plastics/Polymers
- Composites
- Ceramics
- Fluids
- Glasses
- Bio/Natural Materials
- New/Advanced Materials

Manufacturing Processes
- Additive Manufacturing Processes
- Biomanufacturing
- Casting/Molding
- Composite Manufacturing
- Electronic/Electronics Manufacturing
- Heat Treatment/Heat Transfer/Thermal Processes
- Joining and Fabrication and Finishing
- Material Removal/Subtractive Processes
- Material Forming Processes (bulk, sheet)
- Nanomanufacturing
- Assembly
- Non-Traditional Manufacturing

Product Design
- Engineering Graphics (CAE/CAM/CAD)
- Market/Market Cycle Analysis
- Intellectual Property Protection
- Design/Change Management
- Product Liability
- Simulation/Engineering Design/Digital Twin
- Design for X (Mfg/Assemble/Recycling, Sustainability etc.)
- Reliability Analysis/D.O.T.
- Generative Design
- Systems Engineering
- Product Design/Analysis/Design
- LCA Tools and ELM
- Design Thinking

Process Design
- CAD/CAM/CIM/Computer Integrated Manufacturing
- Model-Based Process Design
- Revision Control and Data Management
- Process Development and Test
- Process Research and Design
- Product Prototype Build and Test
- Simulation/Process Analysis/Digital Twin
- Tool and Equipment Selection
- Process Planning and Development
- Computer Aided Process Planning (CAPP)
- Mfg/Assemble/Recycling
- New Process/ New Product Introduction

Equipment/Tool Design
- Cutting Tool Selection and Design
- Workhold/Tool Design
- Die/Mold Designs
- Gauge Design
- Machine Design
- Real-Time Adaptive Control design for tool condition monitoring

Production System Design
- Manufacturing System Design
- Facility Planning/Plant Layout
- Human Factors
- Environmental Sustainability and Protection
- Safety
- Production System Build and Test
- Process Documentation
- Capacity Planning
- Maintenance Systems
- Work instructions
- ERP/MES
- Material Handling and Packaging Systems

Quality and Continuous Improvement
- Process Capability Analysis
- Customer Focus
- Concurrent Engineering
- Continuous Improvement and Lean Mfg
- Consumer & Field Service
- Design of Experiments (DOE)
- Quality Function Deployment
- Inspection Test Validation
- Metrology and Instrumentation
- Quality Systems & Standards
- Reliability Analysis
- Problem Solving and Root Cause Corrective Action
- Quality Management Systems (QMS)
- Statistical Process Control

Industry 4.0 and Automated Systems and Controls
- Cyber Physical Systems/Cybersecurity
- Industry Internet of Things
- Power Systems (Mech/Elec/Fuel)
- Control Systems (Mech/Elec/Fuel)
- CIC/IC/MCS/Computer Control Systems
- Informatics and data analytics
- Mechatronics
- Artificial Intelligence and Machine Learning
- Machine Vision

Manufacturing Management
- Strategic Planning Including:
  - Social, Environmental, Governance, and ESG
  - Competitive Analysis Including
    - Intellectual Property
  - Risk Management
  - Leadership and Project Management
  - Workforce Development – Personnel Management/Talent Relations
  - Operations: Research/Forecasting
  - Supply Chain and Logistics
  - Accounting/Finance/Economics
  - Business/Engineering Ethics
  - Standards, Laws, Regulations
  - Problem Analysis and Solving
  - Knowledge Management (Capture and reuse)

Personal Effectiveness
- Presentation Skills, Conflict Management, Negotiation Skills, Written and Oral Communication
- Professional skills – Interpersonal Skills and Lifelong Learning
- Emotional Intelligence, Diversity, Equity & Inclusiveness (DEI)
- Social Responsibility, Ethics, Innovation and Creativity

Analytic Geometry, Algebra, Biological Sciences, Calculus, Chemistry, Physics, Probability/Statistics, Trigonometry

Mathematics and Science

Analytic Geometry, Algebra, Biological Sciences, Calculus, Chemistry, Physics, Probability/Statistics, Trigonometry

Mathematics and Science
The 4 PILLARS of MANUFACTURING KNOWLEDGE

PRODUCT PRODUCING ENTERPRISE

Customer focus - Quality & Continuous Improvement - Metrology - SPC - Problem Analysis (FMEA, DOE, etc.)
Capability Analysis - Reliability System Thinking - Product Design - Manufacturing Processes
Production System Design - Measurement of Process Variables - Process Improvement

Materials and Manufacturing Processes
Engineering Sciences
Materials
Manufacturing Processes

Engineering Sciences
Statics and Dynamics
Mechanics of Materials
Fluid Mechanics
Thermodynamics/Heat Transfer
Electrical Circuits/Electronics/Instrumentation
Material Science

Engineering Materials
Metals
Plastics/Polymer
Composites
Ceramics
Fluids
Glasses
Bio/Natural Materials
New/Advanced Materials

Manufacturing Processes
Additive Manufacturing Processes
Biomanufacturing
Casting, Molding
Composite Manufacturing
Electrical/Electronics Manufacturing
Heat Treatment/Heat Transfer or Thermal Processes
Joining and Fabrication and Finishing
Material Removal / Subtractive Processes
Material Forming Processes (bulk, sheet)
Nanomanufacturing
Assembly
Non-Traditional Manufacturing
The 4 PILLARS of MANUFACTURING KNOWLEDGE

PRODUCT PRODUCING ENTERPRISE

Customer focus - Quality & Continuous Improvement - Metrology - SPC - Problem Analysis (FMEA, DOE, etc.)
Capability Analysis - Reliability System Thinking - Product Design - Manufacturing Processes
Production System Design - Measurement of Process Variables - Process Improvement

Product, Tooling and Assembly Engineering

Product Design
Process Design
Equipment/Tool Design

Product Design
Engineering Graphics (CAD/CAM/CAE)
Market/Sales/Lifecycle Analysis
Intellectual Property Protection
Design/Change Management
Product Liability
Simulation/Engineering Design/Digital Twin
Design for X (Mfg/Assy/Maint/Remfg/
Recycling, Sustainability etc.)
Tolerance Analysis/GD & T
Generative Analysis
Systems Engineering
Product Lifecycle Management
LCA tools and ELM
Design Thinking

Process Design
CAD/CAM/CIM/Computer
Integrated Manufacturing
Model-Based Process Design
Revision Control and Data Management
Process Development and Test
Process Research and Design
Product Prototype Build and Test
Simulation/Process Analysis/Digital Twin
Tool and Equipment Selection
Process Planning and Development/
Computer Aided Process Planning (CAPP)
MRL/TRL/New Process/
New Product Introduction

Equipment/Tool Design
Cutting Tool Selection and Design
Work Holding Tool Design
Die/Mold Designs
Gage Design
Machine Design
Real Time Adaptive Control design for
tool condition monitoring
The **4 Pillars** of Manufacturing Knowledge

**PRODUCT PRODUCING ENTERPRISE**

- Customer focus - Quality & Continuous Improvement - Metrology - SPC - Problem Analysis (FMEA, DOE, etc.)
- Capability Analysis - Reliability System Thinking - Product Design - Manufacturing Processes
- Production System Design - Measurement of Process Variables - Process Improvement

---

**3**

Manufacturing Systems and Operations

Product System Design

Automated Systems and Control

---

**Production System Design**

- Manufacturing System Design
- Facility Planning/Plant Layout
- Human Factors
- Environmental Sustainability and Protection
- Safety
- Production System Build and Test
- Process Documentation
- Capacity Planning
- Maintenance Systems
- Work Instructions
- ERP/MES
- Material Handling and Packaging Systems

---

**Industry 4.0 and Automated Systems and Controls**

- Cyber Physical Systems/Cybersecurity
- Industry Internet of Things
- Power Systems (Mech./Elec./Fluid)
- Control Systems (Mech./Elec./Fluid)
- CNC/PLC/FMS/Computer Control Systems
- Informatics and data analytics
- Mechatronics
- Artificial Intelligence and Machine Learning
- Machine Vision
The 4 PILLARS of MANUFACTURING KNOWLEDGE

PRODUCT PRODUCING ENTERPRISE

Customer focus - Quality & Continuous Improvement - Metrology - SPC - Problem Analysis (FMEA, DOE, etc.)
Capability Analysis - Reliability System Thinking - Product Design - Manufacturing Processes
Production System Design - Measurement of Process Variables - Process Improvement

Manufacturing Competitiveness

Quality
Continuous Improvement
Manufacturing Management

Quality and Continuous Improvement

- Process Capability Analysis
- Customer Focus
- Concurrent Engineering
- Continuous Improvement and Lean Mfg
- Consumer & Field Service
- Design of Experiments (DOE)
- Quality Function Deployment
- Inspection Test Validation
- Metrology and Instrumentation
- Quality Systems & Standards
- Reliability Analysis
- Problem Solving and Root Cause Corrective Action
- Quality Management Systems (QMS)
- Statistical Process Control

Manufacturing Management

- Strategic Planning Including:
  - Social Environmental, Governance, and DEI
- Competitive Analysis Including:
  - Intellectual Property
- Risk Management
- Leadership and Project Management
- Workforce Development – Personnel
- Management/Labor Relations
- Operations Research/Forecasting
- Supply Chain and Logistics
- Accounting/Finance/Economics
- Business/Engineering Ethics
- Standards, Law, Regulations
- Problem Analysis and Solving
- Knowledge Management (Capture and reuse)