CERTIFIED ADDITIVE MANUFACTURING FUNDAMENTALS (CAMF)

BODY OF KNOWLEDGE

sme®

sme.org/CAMF

CERTIFIED ADDITIVE MANUFACTURING FUNDAMENTALS

BODY OF KNOWLEDGE 2024

Topics	Importance	Competency	Fundamentals Weighting
1.0. OVERVIEW			**30%**
1.1. Key AM Terminology and Definition	High	Remember and Understand	
1.1.1. AM/3D Printer/Printing			
1.1.2. 3D Scanning			
1.1.3. Hybrid Manufacturing			
1.1.4. Rapid Prototyping			
1.1.5. Rapid Tooling			
1.1.6. Subtractive Manufacturing			
1.2. Key Steps	High	Remember and Understand	
1.2.1. Generate a 3D model			
1.2.2. File Conversion			
1.2.3. File Transfer to Machine			
1.2.4. Machine Setup			
1.2.5. Build			
1.2.6. Remove			
1.2.7. Post Processing			
1.2.8. Part Inspection			
1.2.9. Quality Assurance			
1.2.10. Secondary Processing			
1.2.11. Application			
1.3. Uses of AM Parts	High	Remember and Understand	
1.3.1. Prototyping			
1.3.2. Functional Parts			
1.4. Industries Using AM	Medium	Remember and Understand	
1.4.1. Aerospace and Aviation/Defense			
1.4.2. Architecture and Construction			
1.4.3. Art and Fashion			
1.4.4. Consumer Products			

Topics	Importance	Competency	Fundamentals Weighting
1.4.5. Food and Pharmaceutical			
1.4.6. Manufacturing and Industrial			
1.4.7. Medical Devices and Products			
1.4.8. Transportation			
1.5. AM Processes	High	Apply and Analyze	
1.5.1. Binder Jetting			
1.5.2. Directed Energy Deposition			
1.5.3. Material Extrusion			
1.5.4. Material Jetting			
1.5.5. Powder Bed Fusion			
1.5.6. Sheet Lamination			
1.5.7. Vat Photo Polymerization			
1.6. Materials	Medium	Apply and Analyze	
1.6.1. Bio-Materials			
1.6.2. Ceramics			
1.6.3. Composites			
1.6.4. Concrete			
1.6.5. Metals			
1.6.6. Paper			
1.6.7. Plaster			
1.6.8. Polymers			
1.6.9. Sand			
1.6.10. Waxes			
1.6.11. Other Materials (Like Food)			
1.7. Advantages of AM	Medium	Remember and Understand	
1.7.1. AM Integration with Traditional Manufacturing			
1.7.2. Design Complexity			
1.7.3. Design Flexibility			

Topics	Importance	Competency	Fundamentals Weighting
1.7.4. Ease of Prototyping			
1.7.5. Mobility of Production System			
1.7.6. Simplified Set-Up			
1.7.7. Supports Mass Customization			
1.7.8. Sustainability			
1.7.9. Tailoring Material Properties			
1.7.10. Tooling			
1.8. Disadvantages of AM	Medium	Remember and Understand	
1.8.1. Accuracy			
1.8.2. Cost of Technology and ROI			
1.8.3. Inspection			
1.8.4. Material Properties			
1.8.5. Standards are Developing			
1.8.6. Surface Finish			
1.8.7. Workforce Needs Development			
1.9. Foundations of Quality	Medium	Apply and Analyze	
1.9.1. Data Quality			
1.9.2. Feedstock Quality			
1.9.3. Machine Quality Factors			
1.9.4. Output Quality			
1.9.5. Finishing Quality			
2.0. SOFTWARE FLOW			**10%**
2.1. DFAM	Medium	Remember and Understand	
2.1.1. Process Design Guidelines			
2.1.2. Topology Optimization			
2.1.3. Part Consolidation			
2.1.4. Process Simulation			
2.1.5. Customized Infill for Lightweighting			

Topics	Importance	Competency	Fundamentals Weighting
2.2. Data Sources	Medium	Apply and Analyze	
2.2.1. Formats - (STL, AMF)			
2.2.2. Sources - (CAD, Imaging)			
2.3. Data Preparation	High	Apply and Analyze	
2.3.1. Model Evaluation			
2.3.2. Model Repair			
2.3.3. Build Layout			
2.3.4. Support Design and Creation			
2.3.5. Creation of Slice Files			
2.4. In-Situ-Build Monitoring	Medium	Apply and Analyze	
2.4.1. Layer Height			
2.4.2. Temperature			
2.4.3. Process Parameters			
2.5. Post Build Data Management	Medium	Remember and Understand	
2.5.1. Document Build Parameters			
2.5.2. Statistical Process Control			
2.5.2.1. Track Trends of Multiple Builds			
2.5.3. Informal/Formal ERP Systems			
3.0. APPLICATIONS			**5%**
3.1. Applications Discovery and Justification	Low	Remember and Understand	
3.2. Conceptual Prototyping (Form and Fit)	Medium	Remember and Understand	
3.3. Shop Aid (Jigs and Fixtures)	Medium	Remember and Understand	
3.3.1. Alignment and Holding Fixtures			
3.3.2. Measurement Aids			
3.3.3. Tool Storage (Kitting)			
3.4. Tooling	Medium	Remember and Understand	
3.4.1. Sacrifical Tooling			
3.4.1.1. Ceramic Cores			

Topics	Importance	Competency	Fundamentals Weighting
3.4.1.2. Investment Casting Wax/SLA Pattern			
3.4.1.3. Sand Casting			
3.4.1.4. Soluble Cores			
3.4.2. Reusable Tooling			
3.4.2.1. EDM Electrode			
3.4.2.2. Lay up Tooling			
3.4.2.3. Master Patterns			
3.4.2.4. Metal Forming			
3.4.2.5. Mold			
3.4.2.6. Paper Pulp Tooling			
3.4.2.7. Part Fixtures			
3.4.2.8. Thermoforming			
3.5. End Use Parts	Medium	Remember and Understand	
3.5.1. Aerospace and Aviation/Defense			
3.5.1.1. Ceramic (Armor Components, Nozzles, etc.)			
3.5.1.2. Composites (Air Ducts, Structural Parts, etc.)			
3.5.1.3. Concrete (Barricks, Bridges, etc.)			
3.5.1.4. Metals (Brackets, Engines, Fuel Injectors, Munition, Turbine Blades, etc.)			
3.5.1.5. Polymer (Accessories, Air Ducts, Configuration Parts, Non-structural parts, etc.)			
3.5.1.6. 3D Printed Electronics (Antennas, Sensors, etc.)			
3.5.2. Architecture and Construction			
3.5.2.1. Concrete (Bridges, Flooring, Houses, Walls, etc.)			
3.5.2.2. Metal (Bridges, Decorative Elements, Door Hardware, Faucets, Light Switches, etc.)			
3.5.2.3. Plaster (Decorative Elements)			
3.5.2.4. Wood Fiber (Ceiling Fan Propellers, Decorative Elements)			

Topics	Importance	Competency	Fundamentals Weighting
3.5.3. Art and Fashion/Consumer Products			
3.5.3.1. Ceramic (Sculptures, Vases)			
3.5.3.2. Metal (Golf Clubs, Jewelry, Sculptures)			
3.5.3.3. Polymers (Furniture, Helmets, Shoes, Smart Phone Cases)			
3.5.3.4. Wood Fiber (Furniture)			
3.5.4. Food and Pharmaceutical			
3.5.4.1. Medicines (Combination Pills, Pill Structures, Time Release Implants)			
3.5.4.2. Organic Plant Matter (Custom Diet and Nutrition, Decorative Chocolate, Meat Substitutes)			
3.5.5. Manufacturing and Industrial			
3.5.5.1. Metal - (Jigs, Fixtures, Molds, Patterns)			
3.5.5.2. Polymer - (Jigs, Fixtures, Molds, Patterns)			
3.5.5.3. Ceramics (Cores, Molds)			
3.5.5.4. Composites (Machine parts, Jigs, Fixtures)			
3.5.6. Medical Devices and Products			
3.5.6.1. Metals (Artificial Hips, Artificial Knees, Cranial Plates, Dental Implants, Spinal Implants)			
3.5.6.2. Polymers (Aligners, Cranial Plates, Hearing Aids, Planning Models, Prosthetics, Spinal Implants, Surgical Guides)			
3.5.6.3. Ceramics (Bone Implants, Dental Implants)			
3.5.7. Transportation			
3.5.7.1. Polymers (Car Bodies, Trim)			
3.5.7.2. Metals (Chassis Parts, Engine Parts)			

Topics	Importance	Competency	Fundamentals Weighting
3.5.7.3. Composites (Air Ducting, Chassis Parts, Suspension Systems, Trim)			
4.0. TECHNOLOGY & METHODS			**28%**
4.1. Binder Jetting	Medium	Remember and Understand	
4.1.1. Description			
4.1.2. Strengths			
4.1.3. Weaknesses			
4.2. Directed Energy Deposition	High	Remember and Understand	
4.2.1. Description			
4.2.2. Strengths			
4.2.3. Weaknesses			
4.3. Direct Write	Medium	Remember and Understand	
4.3.1. Description			
4.3.2. Strengths			
4.3.3. Weaknesses			
4.4. Hybrid Systems	Medium	Remember and Understand	
4.4.1. Description			
4.4.2. Strengths			
4.4.3. Weaknesses			
4.5. Material Extrusion	High	Remember and Understand	
4.5.1. Description			
4.5.2. Strengths			
4.5.3. Weaknesses			
4.6. Material Jetting	High	Remember and Understand	
4.6.1. Description			
4.6.2. Strengths			
4.6.3. Weaknesses			

Topics	Importance	Competency	Fundamentals Weighting
4.7. Powder Bed Fusion	High	Remember and Understand	
4.7.1. Description			
4.7.2. Strengths			
4.7.3. Weaknesses			
4.8. Sheet Lamination	Low	Remember and Understand	
4.8.1. Description			
4.8.2. Strengths			
4.8.3. Weaknesses			
4.9. Vat Photopolymerization	High	Remember and Understand	
4.9.1. Description			
4.9.2. Strengths			
4.9.3. Weaknesses			
5.0. DESIGN FOR ADDITIVE MANUFACTURING (DfAM)			**1%**
5.1. Design Process	Medium	Remember and Understand	
5.2. Design Strengths	Medium	Remember and Understand	
5.3. Design Verification	Medium	Remember and Understand	
5.4. Design Weaknesses	Medium	Remember and Understand	
6.0. BUSINESS & ECONOMICS			**1%**
6.1. Appplication Discovery and Justification	Low	Remember and Understand	
6.2. Capital Purchase	Low	Remember and Understand	
6.2.1. Machine			
6.2.2. Facility Build/Modification			
6.2.3. Ancillary Equipment			
6.2.4. QA System			
6.2.5. Return on Investment			
6.3. Labor	Low	Remember and Understand	
6.3.1. Dedicated Employee Potential			
6.3.2. Roles and Shared Responsibility			

Topics	Importance	Competency	Fundamentals Weighting
6.3.3. Skill Level(s) Required			
6.3.4. Initial/On-going Training			
6.4. Materials	Low	Remember and Understand	
6.4.1. Build Materials - Deliverable			
6.4.2. Support Cost - Consumed			
6.4.3. Post Processing Materials			
6.4.4. Waste Stream			
6.5. Maintenance Costs	Low	Remember and Understand	
6.5.1. Annual Preventive Maintenance			
6.5.2. Downtime Risk			
6.5.3. Energy Consumption			
6.5.4. Upgrades			
6.6. Inspection Costs	Low	Remember and Understand	
6.6.1. Equipment			
6.6.2. Labor			
6.6.3. Sub-Contracted Inspection			
7.0. QUALITY			**4%**
7.1. Applicable Standards	Medium	Remember and Understand	
7.1.1. Quality Management Systems for Production			
7.1.1.1. SAE-AS9100 (Aerospace Quality Management System)			
7.1.1.2. NADCAP (Aerospace Quality System and AM)			
7.1.1.3. ISO-9001 (Quality System)			
7.1.1.4. ISO 13485 (Medical Device QMS)			
7.1.2. Standards for Materials Qualification			
7.1.2.1. SAE AMS			
7.1.2.2. ASTM-ISO Standards			
7.2. Workflow	High	Remember and Understand	

Topics	Importance	Competency	Fundamentals Weighting
7.2.1. Qualified CAD File			
7.2.2. Qualified Material/Material Tracking			
7.2.3. Qualified Machine			
7.2.4. Operator Qualification			
7.2.5. Part Set Up			
7.2.6. Quality Check (In process Inspection)			
7.2.7. Final part inspection			
8.0. POST PROCESSING			**3%**
8.1. Primary Post Processing	High	Remember and Understand	
8.1.1. Detach from Build Plate			
8.1.2. Remove Support Material/Structures			
8.1.3. Thermal/Non-Thermal Properties Enhancement			
8.2. Secondary Post Processing	Medium	Remember and Understand	
8.2.1. Bonding			
8.2.2. Edge Breaking			
8.2.3. Electro Plating			
8.2.4. Machining			
8.2.5. Painting			
9.0. MATERIALS			**4%**
9.1. General Considerations	Medium	Remember and Understand	
9.1.2. Properties			
9.1.3. Qualification			
9.1.4. Vendor Considerations			
9.1.5. Material Life Cycle			
9.2. Biological Materials	Low	Remember and Understand	
9.2.1. Description			
9.2.2. Properties			
9.3. Ceramics	Medium	Remember and Understand	

Topics	Importance	Competency	Fundamentals Weighting
9.3.1. Description			
9.3.2. Properties			
9.4. Composites	Medium	Remember and Understand	
9.4.1. Description			
9.4.2. Properties			
9.5. Metals	Medium	Remember and Understand	
9.5.1. Description			
9.5.2. Properties			
9.6. Paper	Low	Remember and Understand	
9.6.1. Description			
9.6.2. Properties			
9.7. Polymers	Medium	Remember and Understand	
9.7.1. Description			
9.7.2. Properties			
9.8. Sand	Medium	Remember and Understand	
9.8.1. Description			
9.8.2. Properties			
9.9. Wax	Low	Remember and Understand	
9.9.1. Description			
9.9.2. Properties			
10.0. SOFTWARE APPLICATIONS			**1%**
10.1. Design for Additive	Low	Remember and Understand	
10.1.1. Topolgy Optimization			
10.1.2. Generative Design			
10.1.3. Lattice Structure			
10.1.4. Model Decomposition			
10.2. Model and Build Prep and Repair	Medium	Remember and Understand	
10.2.1. Native Format Modeler			

Topics	Importance	Competency	Fundamentals Weighting
10.3. Build Simulation and Compensation	Low	Remember and Understand	
10.4. Machine Control Software	Medium	Remember and Understand	
10.5. Machine Monitoring, Data Collection and Reporting	Medium	Remember and Understand	
10.6. ERP Software	Low	Remember and Understand	
11.0. SAFETY	**High**	**Remember and Understand**	**10%**
11.1. Hazards Associated with AM Processing	High	Remember and Understand	
11.1.1. Mechanical			
11.1.2. Electrical			
11.1.3. Thermal			
11.1.4. Airborne Particles			
11.1.5. Chemicals			
11.2. Personal Protective Equipment	High	Remember and Understand	
11.3. Hazard Communication and Labeling	High	Remember and Understand	
11.4. Use of Safety Data Sheets	High	Remember and Understand	
11.5. Maintenance and Lockout/Tag-Out	High	Remember and Understand	
11.6. Facilities	High	Remember and Understand	
12.0. EMERGING TOPICS	**Medium**	**Remember and Understand**	**3%**
12.1. Robotics	Medium	Remember and Understand	
12.2. Internet of Things (IoT)	Low	Remember and Understand	
12.3. Cloud Computing	Low	Remember and Understand	
12.4. Remote and Autonomous Operations	Low	Remember and Understand	
12.5. Post Processing Techniques/Automation	Medium	Remember and Understand	
12.6. Materials	Medium	Remember and Understand	
12.7. Food and Pharmaceutical	Low	Remember and Understand	
12.8. Artificial Intelligence	Low	Remember and Understand	
12.9. Large Scale	Low	Remember and Understand	