Grade level: 9-12

Course Title: Manufacturing

Topic/Concept: Introduction to CAD & Engineering Design

Time Allotment: 1 week

Unit Sequence: 1

Major Concepts to be learned:

- Engineering design is a structured problem-solving process
- CAD improves precision, communication, and efficiency
- Technology systems work together to solve real-world problems
- Accurate measurement is essential in engineering design

Expected Skills to be demonstrated:

- Engineering design process
- CAD purpose and applications
- Onshape interface navigation

PA Standards/Anchors:	Eligible Content:
3.4.10.A 3.6.10.A 3.7.10.B	Identify steps of the engineering design process Explain the purpose and applications of CAD technology Demonstrate safe and responsible computer lab procedures Navigate the Onshape interface and cloud workspace Recognize basic engineering and drafting terminology

Instructional Strategies:	Assessments:
• Teacher-led demonstrations • Guided software walkthroughs • Interactive vocabulary activities • Engineering design discussions • Small-group exploration activities • Digital scavenger hunts within Onshape	• CAD terminology quiz • Interface exploration activity • Participation and lab procedures check

Grade level: 9-12 **Course Title: Manufacturing** **Topic/Concept: Sketching Fundamentals**

Time Allotment: 1 week **Unit Sequence: 2**

Major Concepts to be learned:

- Precision sketching is the foundation of accurate 3D models
- Constraints communicate design intent and maintain geometry
- Dimensions define size, location, and relationships
- Mathematical relationships are critical in engineering design

Expected Skills to be demonstrated:

- 2D sketch creation
- Constraints and dimensioning
- Fully defined sketches

PA Standards/Anchors:	Eligible Content:
3.7.10.A 3.4.10.B 3.5.10.A	Create basic 2D sketches using CAD sketch tools Apply dimensions and geometric constraints Distinguish between underdefined and fully defined sketches Use coordinate systems and reference geometry

Instructional Strategies:	Assessments:
• Guided sketching tutorials • Teacher modeling demonstrations • Individual sketching exercises • Peer review activities • Measurement and dimensioning practice • Real-world object sketching	• Constrained sketch assignments • Precision drawing check • Sketch accuracy rubric

Grade level: 9-12 **Course Title: Manufacturing** **Topic/Concept: Basic Part Modeling**

Time Allotment: 2 weeks **Unit Sequence: 3**

Major Concepts to be learned:

- 3D models are created from accurate 2D sketches
- Features define the geometry and structure of parts
- Design choices affect manufacturing processes
- Engineering models represent real-world objects accurately

Expected Skills to be demonstrated:

- Extrude and revolve
- Add/remove material
- Feature-based modeling

PA Standards/Anchors:	Eligible Content:
3.4.10.C 3.6.10.C 3.7.10.C	Create solid models using extrude and revolve features Add and remove material using CAD tools Interpret technical drawings and dimensions Explain additive and subtractive modeling concepts Develop models using feature-based design methods

Instructional Strategies:	Assessments:
• Step-by-step modeling demonstrations • Guided practice exercises • Independent modeling assignments • Technical drawing interpretation activities • Design replication challenges • Teacher conferencing and feedback	• 3D part modeling project • Accuracy rubric • CAD feature competency check

Grade level: 9-12 **Course Title: Manufacturing** **Topic/Concept: Advanced Part Design**

Time Allotment: 1 week **Unit Sequence: 4**

Major Concepts to be learned:

- Advanced modeling tools improve efficiency and realism
- Engineers optimize designs for performance and manufacturability
- Repeated features can be automated using CAD tools
- Design modifications impact system performance

Expected Skills to be demonstrated:

- Fillets and chamfers
- Patterns and mirroring
- Multi-feature parts

PA Standards/Anchors:	Eligible Content:
3.4.10.D 3.6.10.D 3.5.10.B	Create advanced features including fillets and chamfers Apply patterns, mirrors, and reference geometry Analyze how features impact functionality and manufacturability Modify and optimize part designs Compare alternative design solutions

Instructional Strategies:	Assessments:
• Feature demonstration lessons • Reverse engineering activities • Guided optimization exercises • Collaborative troubleshooting • Design comparison activities • Peer critique sessions	• Complex part design challenge • Peer design review • Feature application rubric

Grade level: 9-12 **Course Title: Manufacturing** **Topic/Concept: Assembiles & Systems**

Time Allotment: 2 weeks **Unit Sequence: 5**

Major Concepts to be learned:

- Engineering systems consist of interacting components
- Assemblies simulate real-world mechanical motion
- Proper constraints ensure functionality and movement
- Systems thinking improves engineering problem-solving

Expected Skills to be demonstrated:

- Assembly creation
- Mates and motion
- Interference detection

PA Standards/Anchors:	Eligible Content:
3.6.10.A 3.4.10.E 3.5.10.C	Assemble multiple components into functioning systems Apply mates and constraints to control movement Identify interference and assembly conflicts Analyze relationships between components in a system Explain systems thinking in engineering design

Instructional Strategies:	Assessments:
• Assembly demonstrations • Guided system-building projects • Motion simulation activities • Team-based engineering tasks • Troubleshooting exercises • Hands-on mechanism analysis	• Functional assembly project • Motion demonstration • Assembly functionality rubric

Grade level: 9-12

Course Title: Manufacturing

Topic/Concept: Technical Drawing & Documentation

Time Allotment: 2 weeks

Unit Sequence: 6

Major Concepts to be learned:

- Technical drawings communicate manufacturing information
- Standard drafting practices improve clarity and accuracy
- Engineers use drawings to communicate design intent
- Multiple views fully describe an object

Expected Skills to be demonstrated:

- Orthographic projection
- Dimensioning standards
- Section/detail views

PA Standards/Anchors:	Eligible Content:
3.7.10.C 3.4.10.F 3.5.10.D	Create orthographic projections and multiview drawings Apply standard dimensioning practices Produce section and detail views Interpret engineering drawing conventions Communicate technical information accurately

Instructional Strategies:	Assessments:
• Blueprint reading activities • Teacher-led drawing demonstrations • Dimensioning practice exercises • Peer drawing critiques • Technical print analysis • Independent documentation projects	• Multi-view drawing project • Blueprint rubric • Technical communication evaluation

Grade level: 9-12

Course Title: Manufacturing

Topic/Concept: Parametric Design & Variables

Time Allotment: 1 week

Unit Sequence: 7

Major Concepts to be learned:

- Parametric design improves adaptability and efficiency
- Variables and equations automate engineering relationships
- Configurations reduce repetitive modeling tasks
- Design intent allows models to update predictably
- Mathematical relationships are essential in engineering design

Expected Skills to be demonstrated:

- Variables and equations
- Configurations
- Design intent modification

PA Standards/Anchors:	Eligible Content:
3.4.10.B 3.5.10.B 3.6.10.B	Create and apply variables within CAD models Use equations to control dimensions and geometry Develop multiple configurations of a design Modify models while maintaining design intent Analyze efficiency improvements through parametric design

Instructional Strategies:	Assessments:
• Guided variable setup demonstrations • Design-change simulation activities • Independent modeling exercises • Problem-solving challenges • Collaborative troubleshooting sessions • Real-world engineering examples	• Parametric model assignment • Design-change challenge • Configuration accuracy check

Grade level: 9-12

Course Title: Manufacturing

Topic/Concept: Measurement, Testing, & Analysis

Time Allotment: 1 week

Unit Sequence: 8

Major Concepts to be learned:

- Measurement verifies engineering accuracy
- Testing and analysis improve product performance
- Tolerances affect manufacturing and assembly success
- Data-driven decisions improve engineering outcomes
- Accurate measurement is critical to quality control

Expected Skills to be demonstrated:

- Mass properties
- Measurement tools
- Tolerances (intro)

PA Standards/Anchors:	Eligible Content:
3.7.10.B 3.4.10.D 3.6.10.C	Use CAD measurement tools to analyze models Calculate mass properties and dimensions Apply introductory tolerance concepts Evaluate design accuracy and functionality Analyze relationships between measurements and performance

Instructional Strategies:	Assessments:
• Measurement labs • Guided analysis activities • Real-world tolerance examples • CAD inspection exercises • Data interpretation practice • Small-group problem solving	• Measurement lab • Analysis worksheet • Tolerance evaluation activity

Grade level: 9-12 **Course Title: Manufacturing** **Topic/Concept: Manufacturing & Protyping**

Time Allotment: 1-2 weeks **Unit Sequence: 9**

Major Concepts to be learned:

- Manufacturing transforms designs into usable products
- Material selection impacts cost and performance
- Prototyping allows engineers to test and improve designs
- Digital manufacturing improves efficiency and precision
- Engineers must design with manufacturing constraints in mind

Expected Skills to be demonstrated:

- 3D printing prep (STL export)
- Materials selection
- Intro to CNC concepts

PA Standards/Anchors:	Eligible Content:
3.6.10.C 3.4.10.G 3.5.10.A	Prepare CAD files for 3D printing Export STL files for manufacturing Compare manufacturing methods and materials Explain introductory CNC machining concepts Evaluate manufacturability of engineered products

Instructional Strategies:	Assessments:
• Additive manufacturing demonstrations • Prototype evaluation activities • Material comparison labs • Manufacturing process discussions • Project-based learning activities • Real-world product analysis	• Protype design project • Manufacturing plan • Material selection justification

Grade level: 9-12

Course Title: Manufacturing

Topic/Concept: Collaboration & Cloud-Based Design

Time Allotment: 1 week

Unit Sequence: 10

Major Concepts to be learned:

- Modern engineering relies on collaboration and communication
- Cloud-based tools improve workflow efficiency
- Version control protects design integrity
- Engineering teams share responsibilities and ideas
- Digital communication supports global engineering projects

Expected Skills to be demonstrated:

- Sharing and permissions in Onshape
- Version control
- Collaborative workflows

PA Standards/Anchors:	Eligible Content:
3.5.10.D 3.6.10.E 3.4.10.F	Share and manage CAD files using cloud platforms Apply version control and revision tracking Collaborate effectively within engineering teams Analyze the impact of communication technology Present engineering solutions digitally

Instructional Strategies:	Assessments:
• Team-based CAD projects • Shared modeling activities • Peer feedback sessions • Collaborative problem-solving exercises • Teacher-facilitated teamwork discussions • Digital presentation activities	• Team design mini-project • Revision history check • Collaboration rubric

Grade level: 9-12

Course Title: Manufacturing

Topic/Concept: Introduction to Manufacturing

Time Allotment: 2 weeks

Unit Sequence: 11

Major Concepts to be learned:

- Definition and purpose of manufacturing
- Importance of manufacturing in society
- Economic impact of manufacturing
- Manufacturing systems and processes
- Manufacturing value-added concepts

Expected Skills to be demonstrated:

- Define manufacturing and its role in society
- Identify products created through manufacturing
- Explain how manufacturing affects the economy
- Describe the relationship between raw materials and finished products

PA Standards/Anchors:	Eligible Content:
3.4.10.A 3.4.10.B 3.6.10.A 15.4.12.A	Manufacturing systems Technological impacts on society Economic influences of manufacturing Product development concepts

Instructional Strategies:	Assessments:
• Direct instruction • Guided notes • Class discussion • Manufacturing product identification activity • Manufacturing process mapping	• Vocabulary quiz • Manufacturing process worksheet • Exit tickets • Unit test

Grade level: 9-12

Course Title: Manufacturing

Topic/Concept: History of Manufacturing & Industry Development

Time Allotment: 2 weeks

Unit Sequence: 12

Major Concepts to be learned:

- Pre-industrial production methods
- Industrial Revolution
- Mass production
- Interchangeable parts
- Evolution of manufacturing technologies

Expected Skills to be demonstrated:

- Compare historical and modern manufacturing methods
- Analyze effects of industrialization
- Explain technological advances in manufacturing

PA Standards/Anchors:	Eligible Content:
3.4.10.C 3.6.10.D 8.3.12.A	Technological change over time Historical manufacturing developments Industrial Revolution impacts

Instructional Strategies:	Assessments:
• Video analysis • Timeline creation • Historical case studies • Research activities	• Video summary writing • Manufacturing timeline project • Quiz • Discussion participation

Grade level: 9-12

Course Title: Manufacturing

Topic/Concept: Manufacturing & the Economy

Time Allotment: 2 weeks

Unit Sequence: 13

Major Concepts to be learned:

- GDP
- MVA (Manufacturing Value Added)
- ISM Reports
- Manufacturing employment statistics
- Economic indicators

Expected Skills to be demonstrated:

- Interpret manufacturing data
- Analyze economic reports
- Explain manufacturing's role in economic growth

PA Standards/Anchors:

3.4.10.B
15.4.12.C
15.4.12.D

Eligible Content:

Economic measurement systems
Production analysis
Labor and workforce considerations

Instructional Strategies:

- Data analysis
- Current events research
- Graph interpretation
- Cooperative learning

Assessments:

- Data analysis worksheet
- Economic report presentation
- Quiz
- Reflection assignment

Grade level: 9-12 **Course Title: Manufacturing** **Topic/Concept: Types of Manufacturing**

Time Allotment: 2 weeks **Unit Sequence: 14**

Major Concepts to be learned:

- Additive Manufacturing
- Advanced Manufacturing
- Contract Manufacturing
- Manufacturing careers

Expected Skills to be demonstrated:

- Compare manufacturing methods
- Select appropriate manufacturing techniques
- Identify career pathways

PA Standards/Anchors:	Eligible Content:
3.4.10.E 3.6.10.C 13.1.11.A	Manufacturing technologies Production systems Career awareness

Instructional Strategies:	Assessments:
• Career research • Technology demonstrations • Group presentations • Industry case studies	• Career research project • Manufacturing comparison chart • Quiz • Presentation rubric

Grade level: 9-12

Course Title: Manufacturing

Topic/Concept: Manufacturing Processes & Techniques

Time Allotment: 2 weeks

Unit Sequence: 15

Major Concepts to be learned:

- Discrete Manufacturing
- Process Manufacturing
- Lean Manufacturing
- Six Sigma
- Job Shop Manufacturing
- Just-In-Time Manufacturing
- MTS, MTO, MTA

Expected Skills to be demonstrated:

- Differentiate manufacturing processes
- Evaluate production efficiency
- Apply lean manufacturing concepts

PA Standards/Anchors:	Eligible Content:
3.6.10.B 3.6.10.C 15.4.12.E	Process improvement Quality systems Manufacturing efficiency

Instructional Strategies:	Assessments:
• Simulations • Production line activities • Problem-based learning • Team challenges	• Lean manufacturing activity • Process comparison project • Unit test

Grade level: 9-12

Course Title: Manufacturing

Topic/Concept: Product Development & Design

Time Allotment: 2 weeks

Unit Sequence: 16

Major Concepts to be learned:

- Seven-step manufacturing process
- Product vision
- Market research
- Product design
- Cost analysis
- Research and Development (R&D)

Expected Skills to be demonstrated:

- Conduct market research
- Identify customer needs
- Develop product concepts
- Create design solutions
- Analyze product feasibility

PA Standards/Anchors:	Eligible Content:
3.6.10.A 3.6.10.D 3.2.10.A	Engineering design process Product development Research methods

Instructional Strategies:	Assessments:
• Design challenges • Research activities • Brainstorming sessions • CAD sketching • Design reviews	• Market research report • Design proposal • Design notebook • Teacher conferences

Grade level: 9-12

Course Title: Manufacturing

Topic/Concept: Prototyping, Testing, & Quality Control

Time Allotment: 2 weeks

Unit Sequence: 17

Major Concepts to be learned:

- Prototype development
- Bill of Materials (BOM)
- Iterative design
- User stories
- Quality control
- Testing procedures
- Feedback analysis

Expected Skills to be demonstrated:

- Develop prototypes
- Create a BOM
- Conduct product testing
- Analyze user feedback
- Improve designs through iteration

PA Standards/Anchors:	Eligible Content:
3.6.10.A 3.6.10.B 3.6.10.D	Prototype development Quality assurance Product evaluation

Instructional Strategies:	Assessments:
• Prototype construction • Peer evaluations • Testing stations • Design reviews	• Prototype evaluation rubric • BOM submission • Testing documentation • Design revision report

Grade level: 9-12 | **Course Title: Manufacturing** | **Topic/Concept: Capstone Manufacturing Project**

Time Allotment: 2 weeks | **Unit Sequence: 18**

Major Concepts to be learned:

- Phase 1: Product Vision & Market Research
- Phase 2: Product Design
- Phase 3: Prototype Development
- Phase 4: Manufacturing & Production Planning
- Phase 5: Final Presentation

Expected Skills to be demonstrated:

- Identify a problem to solve
- Analyze competing products
- Sketch ideas
- Select materials
- Estimate production costs
- Test functionality
- Revise design
- Conduct customer surveys
- Establish product requirements
- Create technical drawings/CAD models
- Develop a Bill of Materials
- Construct prototype
- Gather feedback

PA Standards/Anchors:

3.4.10.A-E
3.6.10.A-D
15.4.12.A-E
13.1.11.A-B

Eligible Content:

Engineering design process
Manufacturing systems
Research and development
Product testing
Technical communication

Instructional Strategies:

- Project-based learning
- Design thinking
- Peer critiques
- Instructor mentoring
- Industry-style presentations

Assessments:

- Design portfolio (25%)
- Research documentation (15%)
- Prototype quality (20%)
- Manufacturing plan (15%)
- Presentation (15%)
- Reflection paper (10%)