Course Title: Innovation and Design

Board Approved: October 2026

Monthly Curriculum Map

Month	Unit/Topics Covered
August/September	•
October	•
November	•
December	•
January	•
February	•
March	•
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May/June	•

Unit: Course intro & Introduction to Innovation & Design Topics	**Time:** 4 weeks

Academic Standards:

3.5.9-12.NN - Analyze the rate of technological and engineering development and predict future diffusion and adoption of new innovations and technologies.

3.5.9-12.KK - Relate how technological and engineering developments have been evolutionary, often the result of a series of refinements to basic inventions or technological knowledge.

3.5.9-12.F - Evaluate a technological innovation that arose from a specific society's unique need or want.

Essential Content/Objective: At the end of the unit, students will be able to:

1. Explain the course purpose, expectations, instructional timeline, grading procedures, and classroom policies.
2. Identify and distinguish sustaining, disruptive, incremental, and radical innovation. Four types of innovation
3. Explain how products evolve through research, feedback, technology, and changing user needs.
4. Analyze how technology, demographics, attention, usability, and the “3 F’s” influence innovation. Five drivers of innovation
5. Explain the Define, Ideate, Prototype, Test, and Produce steps of the design-thinking process.
6. Describe human-centered design and the importance of empathy in solving problems.
7. Apply design-thinking mindsets such as mindfulness of process, showing rather than telling, bias toward action, radical collaboration, and a culture of prototyping.
8. Evaluate products using universal design, circular design, ergonomics, aesthetics, functionality, and user experience.
9. Explain the basic purpose of patents and intellectual-property protection.
10. Distinguish among utility, design, and plant patents.

Core Student Activities: Students will complete/participate in the following:

1. Participate in a course orientation and review the syllabus, timeline, grading procedures, and classroom expectations.
2. Set up an engineering notebook or digital design portfolio.

Assessment:

1. Course-expectations or syllabus exit quiz
2. Innovation and design vocabulary assessment
3. Engineering notebook or portfolio entries
4. Class discussion and formative questioning
5. Patent presentation rubric

3. Complete an identify innovation assignment
    a. Identify a product for each type of innovation
    b. Sort product examples into sustaining, disruptive, incremental, and radical innovation categories.
    c. Explain the innovation and specify the drivers of the innovative product.
4. Product Evolution Assignment (incremental innovation)
    a. Research & develop a product-evolution timeline showing at least three stages of development.
    b. Compare an original product with its current version.
5. Design Thinking Worksheet
    a. Lecture, class discussion, & note taking
6. Patent Worksheet
    a. Lecture, class discussion, & note taking
7. Patent Assignment
    a. Research existing patents
    b. Identify whether a patent is a utility, design, or plant patent.
    c. Analyze the patent and summarize

Materials and Resources:

1. Course syllabus and permission slip
2. Class introduction Google slide
    a. Classroom policies and grading procedures
3. Engineering notebooks and digital portfolios
4. Innovation and design vocabulary resources
5. Project rubrics, peer-feedback forms, and reflection prompts
6. Product samples and consumer products
7. Innovation-classification cards and case studies
8. Design-thinking worksheet
9. Approved patent-search databases

Instructional Methods:

1. Direct instruction and focused mini-lessons
2. Lecture and class discussion
3. Teacher modeling and think-aloud demonstrations

Extensions:

1. Compare how the same innovation developed in different cultures or time periods.
2. Investigate how an emerging technology may disrupt an existing industry.
3. Research the inventor, engineering team, or company behind a product.
4. Complete a life-cycle analysis of a consumer product.
5. Interview a local inventor, designer, engineer, or entrepreneur.

Remediation:

4. Guided note-taking 5. Individual and collaborative problem-solving 6. Project-based learning	1. Review essential vocabulary using visual examples and word walls. 2. Use sorting cards and matching activities. 3. Provide approved websites and preselected patent examples. 4. Allow students to revise or reassess after additional instruction.

Unit: Math skill sets for Innovation & Design	**Time:** 1 week

Academic Standards:

3.5.9-12.BB - Assess how similarities and differences among scientific, technological, engineering, and mathematical knowledge and skills contributed to the design of a product or system.

3.5.9-12.DD - Develop a plan that incorporates knowledge from science, mathematics, and other disciplines to design or improve a technological product or system.

3.5.9-12.PP - Demonstrate the use of conceptual, graphical, virtual, mathematical, and physical modeling to identify conflicting considerations before the entire system is developed and to aid in design decision making.

Essential Content/Objective: At the end of the unit, students will be able to:

1. Utilize the customary and Metric systems of measurement and present measurements in simplest form.
2. Add, Subtract, and divide fractions and present them in simplest form.
3. Model and compare values of integers, mixed numbers, fractions, and decimals.
4. Explain how mathematics supports accurate design, modeling, fabrication, testing, and quality control.
5. Select and correctly use rulers, tape measures, scales, protractors, and calipers.
6. Read and record customary measurements using fractions of an inch.
7. Read and record metric measurements using millimeters, centimeters, and meters.
8. Convert between fractions, decimals, and percentages.

Core Student Activities: Students will complete/participate in the following:

1. Measurement Worksheet
    a. Lesson on measurement and application
    b. Identify the parts and scales of common measuring tools.
    c. Add, subtract, multiply, and divide fractions and mixed numbers.
    d. Convert fractions to decimals and decimals to fractions.
    e. Complete customary and metric conversion problems.
    f. Convert dimensions between inches and millimeters.
2. Measurement station activity

Assessment:

1. Diagnostic pre-assessment
2. Exit tickets and formative checks
3. Measurement unit quiz
4. Class participation

a. Practice reading customary and metric rulers.
b. Compare measurements collected with different tools.
c. Measure objects and record dimensions using fractions, decimals, and metric units.
d. Create a scaled drawing from actual measurements.
e. Calculate the surface area and volume of three-dimensional objects.

Materials and Resources:

1. Customary and metric rulers
2. Tape measures and measuring tapes
3. Architect's and engineer's scales
4. digital calipers
5. Calculators
6. Measurement worksheets and station cards
7. Solid geometric shapes

Instructional Methods:

1. Direct instruction and focused mini-lessons
2. Lecture and class discussion
3. Teacher modeling and think-aloud demonstrations
4. Guided note-taking
5. Individual and collaborative problem-solving
6. Hands-on measurement laboratories
7. Measurement learning stations
8. Project-based application

Extensions:

1. Use digital calipers to collect precision measurements.
2. Compare the precision of different measuring tools.
3. Reverse engineer and dimension a manufactured object.
4. Produce a CAD model from measured dimensions.
5. Scale a design for users of different sizes.

Remediation:

1. Use diagnostic results to identify specific skill gaps.
2. Reteach measurement vocabulary and tool components.
3. Provide enlarged rulers and visual measurement models.
4. Provide conversion charts and formula reference sheets.
5. Provide guided measurement stations with teacher support.
6. Allow calculator use after the underlying concept is demonstrated.
7. Allow reassessment after targeted instruction and practice.

Unit: CNC Machine and Tool Use/Safety	**Time:** 2 weeks- Throughout Course

Academic Standards:

3.5.9-12.AA - Safely apply an appropriate range of making skills to a design thinking process.

3.5.9-12.I (ETS) - Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

3.5.9-12.O - Apply appropriate design thinking processes to diagnose, adjust, and repair systems to ensure precise, safe, and proper functionality.

Essential Content/Objective: At the end of the unit, students will be able to:

1. Follow safety rules concerning clothing, footwear, long hair, jewelry, distractions, and restricted operating areas.
2. Follow the necessary precautions prior to using or starting any machine.
3. Demonstrate effective practice of eliminating hazards, poor decisions, and unsafe conditions that could lead to accidents.
4. Safely operate a CNC laser engraver/cutter, CNC router, table saw, router, band saw, scroll saw, drill press, disk and belt sander, hand drill, etc.
5. Safely use hand tools- hammer, screwdriver, hand saw, coping saw, hacksaw, sandpaper
6. Recognize hazards involving cutting tools, rotating parts, pinch points, entanglement, material ejection, chips, dust, noise, heat, and electricity.
7. Explain the purpose of guards, enclosures, interlocks, emergency stops, ventilation, dust collection, and workholding devices.
8. Select and correctly use required personal protective equipment.
9. Recognize abnormal sounds, vibration, smoke, loose material, broken tooling, or other unsafe conditions.

Core Student Activities: Students will complete/participate in the following:

1. Participate in an equipment-specific safety orientation.
    a. Observe a teacher demonstration of setup, operation, shutdown, and cleanup.

Assessment:

1. Equipment-specific safety quiz
2. CNC terminology assessment
3. Written Correction and explanation of missed safety questions
4. Mini CNC project rubric

b. Review the standard operating procedure and emergency plan. c. Demonstrate correct PPE, clothing, hair, and jewelry practices. d. Machine and tool practice with teacher supervision e. Demonstrate the correct response to abnormal-operation scenarios. f. Safety reviews 2. Hands-on lab work a. Complete a pre-operation inspection checklist. b. Review file units, dimensions, origin, material orientation, and toolpath settings. c. Simulate or preview an instructor-approved toolpath. d. Set up and produce a simple CNC project under direct supervision.	
Materials and Resources: 1. Class safety rules and standard operating procedures 2. Emergency-action procedures 3. Safety presentations, videos, and hazard scenarios 4. CNC equipment and installed safety systems 5. Computers with CAD, CAM, and toolpath-simulation software 6. Instructor-approved design files and materials 7. Machine-compatible tools and accessories 8. Safety quizzes, performance checklists, and authorization forms **Instructional Methods:** 1. Direct safety instruction 2. Equipment-specific teacher demonstrations 3. Teacher think-aloud modeling 4. CAD/CAM simulation 5. Supervised hands-on operation 6. Formative questioning and immediate corrective feedback	**Extensions:** 1. Develop a machine setup sheet. 2. Design a jig or fixture that improves workholding safety. 3. Analyze a toolpath for possible collisions or inefficiencies. 4. Create a CNC safety poster, infographic, or instructional video. 5. Complete an advanced instructor-approved CNC project. **Remediation:** 1. Provide labeled diagrams and visual safety guides. 2. Break operating procedures into smaller sequential tasks. 3. Conduct individual or small-group safety instruction. 4. Use a simplified instructor-approved project. 5. Allow repeated attempts to demonstrate competency.

Unit: Design Project (Define step)	**Time:** 2 weeks

Academic Standards:

3.5.9-12.U - Evaluate and define the purpose of a design.

3.5.9-12.N - Analyze and use relevant and appropriate design thinking processes to solve technological and engineering problems.

3.5.9-12.V - Apply principles of human-centered design.

3.5.9-12. Y (ETS) - Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Essential Content/Objective: At the end of the unit, students will be able to:

1. Explain the purpose of the Define step within the design-thinking process.
2. Use empathy to investigate users' experiences, needs, behaviors, and frustrations.
3. Conduct ethical observations, interviews, surveys, and product evaluations.
4. Distinguish between user needs, user wants, assumptions, and personal preferences.
5. Evaluate an existing product's function, usability, safety, accessibility, aesthetics, and sustainability.
6. Identify design flaws, product failures, and opportunities for improvement.
7. Write a focused, user-centered problem statement.
8. Establish measurable design criteria and realistic constraints.

Core Student Activities: Students will complete/participate in the following:

1. Complete a Bug List identifying products that do not work as intended. Bug List
    a. Identify 10 items/products that do not work as intended or have design flaws that limit usability.
2. Product evaluation
    a. Use the product and document its strengths, weaknesses, and limitations.

Assessment:

1. Engineering notebook or portfolio
2. Student self-assessment and reflection
3. Teacher observation and project rubric

b. Observe users interacting with the product or completing a related task. c. Develop and conduct user interviews or surveys. d. Record user comments, behaviors, needs, frustrations, and workarounds. 3. Review the design challenge and identify known and unknown information. 4. Research existing products and competing solutions. 5. Create a list of measurable design criteria and project constraints. 6. Document research, analysis, and revisions in an engineering notebook or portfolio.	
Materials and Resources: 1. Design challenge or project prompt 2. Existing products or product samples 3. Engineering notebooks and design portfolios 4. Bug List and product-evaluation templates 5. Cameras or mobile devices for documentation 6. Sticky notes, index cards, and chart paper 7. Whiteboards and dry-erase markers 8. Measuring tools, including rulers, scales, and calipers 9. Product reviews, manufacturer information, and consumer reports **Instructional Methods:** 1. Direct instruction and focused mini-lessons 2. Teacher modeling of observation, interviewing, and problem framing 3. User-centered design instruction 4. Guided product evaluation 5. Hands-on product investigation 6. Think-pair-share and collaborative discussion 7. Small-group interviews and role-playing 8. Individual and collaborative problem-solving	**Extensions:** 1. Study the needs of users with different physical, sensory, or cognitive abilities. 2. Compare how the problem affects users from different age groups or cultures. 3. Analyze the product's environmental life cycle. 4. Investigate ethical, social, cultural, or environmental impacts. **Remediation:** 1. Use a teacher-selected product or design problem. 2. Provide structured observation, interview, and survey templates. 3. Supply question stems for user interviews. 4. Use role-playing before students interview actual users. 5. Provide frequent checkpoints and individual feedback.

Unit: Reverse Engineering	**Time:** 1 week

Academic Standards:

3.5.9-12.LL - Analyze the stability of a technological system and how it is influenced by all of the components in the system, especially those in the feedback loop.

3.5.9-12.MM - Troubleshoot and improve a flawed system embedded within a larger technological, social, or environmental system.

3.5.9-12.O - Apply appropriate design thinking processes to diagnose, adjust, and repair systems to ensure precise, safe, and proper functionality.

3.5.9-12.A - Use various approaches to communicate processes and procedures for using, maintaining, and assessing technological products and systems.

Essential Content/Objective: At the end of the unit, students will be able to:

1. Define reverse engineering and explain its role in understanding, repairing, evaluating, and improving products.
2. Identify a product as a system composed of interconnected components and subsystems.
3. Evaluate a product for potential electrical, mechanical, chemical, thermal, and material hazards before disassembly.
4. Select and safely use appropriate tools for disassembling an approved, de-energized product.
5. Develop and follow a logical disassembly plan.
6. Document a product's original condition, dimensions, features, and operation.
7. Explain the function of individual components and how they interact within the system.
8. Create a detailed parts list and sequential disassembly/reassembly record.
9. Analyze a product for failure points, design limitations, usability concerns, and maintenance challenges.
10. Communicate reverse-engineering findings through technical writing, diagrams, photographs, models, and presentations.

Core Student Activities: Students will complete/participate in the following:

Assessment:

1. Engineering notebook or design portfolio
2. Reverse-engineering report
3. Student self-assessment and reflection
4. Teacher observation and project rubric

1. Select a teacher-approved product for reverse engineering.
    a. Photograph and document the product's original condition.
    b. Observe and test the product's intended function when safe and appropriate.
    c. Complete a product hazard assessment before beginning work.
    d. Prepare a disassembly plan and select appropriate tools.
    e. Identify ways of improving the product
2. Carefully disassemble the product
    a. Document the process of disassembling the product
    b. Create a detailed parts list with specific fastener types and sizes
    Product Parts list
    c. Photograph and label each stage of the disassembly process.
    d. Analyze how components interact to produce the intended function.
    e. Properly sort reusable parts, recyclable materials, and electronic waste.

Materials and Resources:

1. Teacher-approved, de-energized products or broken devices
2. Engineering notebooks or design portfolios
3. Safety glasses and other required personal protective equipment
4. Screwdrivers and misc hand tools
5. Parts trays, magnetic mats, resealable bags, labels, and markers
6. Cameras, tablets, or mobile devices for documentation
7. Project rubrics and peer-review forms

Instructional Methods:

1. Direct instruction and focused mini-lessons
2. Teacher demonstration of safe disassembly and documentation
3. Hazard-identification and safety instruction
4. Hands-on disassembly and reassembly
5. Project-based learning
6. Teacher think-aloud modeling
7. Individual and group problem-solving

Extensions:

1. Design and 3-D print a replacement or improved component.
2. Develop illustrated disassembly and reassembly instructions.
3. Create a repair guide or product-maintenance manual.
4. Redesign the product for easier repair, recycling, or disassembly.

Remediation:

1. Review reverse-engineering vocabulary and process steps.
2. Provide a teacher-selected product with a simple construction.
3. Model a complete disassembly step before students begin.

	4. Conduct teacher-guided or small-group disassembly. 5. Use a virtual teardown, video, or exploded diagram when physical disassembly is not appropriate. 6. Provide frequent teacher checkpoints and targeted feedback.

Unit: Computer-Aided Design	**Time:** 2 weeks

Academic Standards:

3.5.9-12.PP - Demonstrate the use of conceptual, graphical, virtual, mathematical, and physical modeling to identify conflicting considerations before the entire system is developed and to aid in design decision making.

3.5.9-12.K(ETS) - Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

3.5.9-12.A - Use various approaches to communicate processes and procedures for using, maintaining, and assessing technological products and systems.

Essential Content/Objective: At the end of the unit, students will be able to:

1. Explain how computer-aided design is used to communicate, model, test, and manufacture products.
2. Navigate the user interface of Autodesk Fusion and AutoCAD.
3. Create, name, organize, save, export, and manage CAD files.
4. Apply appropriate units, scales, coordinate systems, grids, and view controls.
5. Create accurate two-dimensional sketches using lines, arcs, circles, polygons, and other geometric tools.
6. Apply geometric constraints and dimensional constraints to control a sketch.
7. Explain the relationship between two-dimensional drawings and three-dimensional objects.
8. Modify dimensions and features while maintaining the design intent of a model.
9. Create technical drawings from a three-dimensional model.
10. Export CAD files in formats appropriate for technical drawings, 3-D printing, laser cutting, or CNC manufacturing.

Core Student Activities: Students will complete/participate in the following:

1. Explore the CAD interface, navigation tools, view cube, browser, timeline, and toolbars.
2. Practice opening, naming, saving, organizing, and exporting CAD files.
3. Complete basic two-dimensional sketching exercises.

Assessment:

1. CAD interface and terminology quiz
2. Engineering notebook or digital portfolio
3. Student self-assessment and reflection
4. Teacher observation and project rubric

4. Apply horizontal, vertical, parallel, perpendicular, tangent, concentric, and symmetry constraints.
5. Dimension sketches using customary and metric measurements.
6. Translate a physical object or paper drawing into a CAD model.
7. Apply fillets, chamfers, holes, shells, patterns, and other modifying features.
8. Measure an existing object with rulers or calipers and reproduce it digitally.
9. Prepare a file for 3-D printing, laser cutting, or CNC manufacturing.
10. Document screenshots, drawings, revisions, and reflections in an engineering portfolio.

Materials and Resources:

1. Computers or laptops capable of running CAD software
2. Autodesk Fusion, AutoCAD, or comparable CAD software
3. Computer mouse with scroll wheel
4. Projector or interactive display
5. Step-by-step tutorials and CAD reference guides
6. Engineering notebooks or design portfolios
7. Graph paper, sketch paper, and tracing paper
8. CAD terminology and command reference sheets
9. Project rubrics and peer-review checklists
10. 3-D printers, laser cutters, CNC machines, or other fabrication equipment

Instructional Methods:

1. Direct instruction and focused mini-lessons
2. Live software demonstrations
3. Teacher think-aloud modeling
4. Guided step-by-step practice
5. Project-based learning
6. Guided inquiry and problem-solving
7. Peer coaching and collaborative troubleshooting
8. Video tutorials and self-paced practice
9. Formative questioning and progress checks

Extensions:

1. Create multi-component assemblies with joints or motion.
2. Apply materials, appearances, lighting, and rendering tools.
3. Design a functional part for 3-D printing.
4. Calculate volume, surface area, center of mass, or material use.
5. Create a product presentation with photorealistic renderings.

Remediation:

1. Review basic computer navigation and file-management skills.
2. Provide a labeled diagram of the CAD interface.
3. Use short, step-by-step video tutorials.
4. Break modeling tasks into smaller, sequential operations.
5. Use physical objects to reinforce the relationship between two-dimensional and three-dimensional representations.

	6. Model common errors and demonstrate how to diagnose and correct them. 7. Conduct small-group or individual CAD instruction. 8. Provide additional time for software practice and assignment completion.

Unit: Design Project (Ideate step)	**Time:** 2 weeks

Academic Standards:

3.5.9-12.N - Analyze and use relevant and appropriate design thinking processes to solve technological and engineering problems.

3.5.9-12.P - Apply a broad range of design skills to a design thinking process.

3.5.9-12.V - Apply principles of human-centered design.

3.5.9-12.S - Conduct research to inform intentional inventions and innovations that address specific needs and wants.

Essential Content/Objective: At the end of the unit, students will be able to:

1. Explain the purpose of ideation within the design-thinking process.
2. Distinguish between divergent thinking and convergent thinking.
3. Research existing products and evaluate how effectively they address the identified problem.
4. Generate a wide range of original solutions before selecting a final concept.
5. Apply brainstorming, brainwriting, mind mapping, SCAMPER, and other ideation strategies.
6. Build on the ideas of others through respectful collaboration.
7. Apply user needs, design criteria, and constraints to proposed solutions.
8. Incorporate universal design, circular design, ergonomics, aesthetics, functionality, and user experience.
9. Communicate design ideas through annotated sketches, diagrams, and written explanations.
10. Select and justify a promising design concept for further development.
11. Document the ideation process and reflect on how ideas changed through feedback.

Core Student Activities: Students will complete/participate in the following:

1. Invention AHA moment Assignment
    a. Research and identify those AHA breakthrough moments that have resulted in the innovative products we used today

Assessment:

1. Concept proposal and presentation
2. Engineering notebook or portfolio documentation
3. Student self-assessment and reflection
4. Teacher observation and project rubric

2. Review the problem statement, user research, criteria, and constraints developed during the Define step. 3. Research and analyze existing products that address similar needs. 4. Participate in individual and collaborative brainstorming sessions. 5. Complete rapid-ideation exercises such as Crazy 8s or timed thumbnail sketching. 6. Use brainwriting, mind maps, SCAMPER, or morphological charts to generate alternatives. 7. Produce multiple annotated concept sketches. 8. Combine promising features from different ideas. 9. Gather feedback from classmates, potential users, and the instructor. 10. Refine the strongest concept based on research and feedback. 11. Prepare a concept proposal that includes sketches, features, materials, and intended user benefits. 12. Present and defend the selected concept. 13. Document research, sketches, feedback, and decisions in an engineering notebook or portfolio.	
Materials and Resources: 1. Design briefs, problem statements, criteria, and constraints 2. Engineering notebooks and design portfolios 3. Sketch paper, graph paper, and tracing paper 4. Pencils, colored pencils, pens, and markers 5. Sticky notes, index cards, and chart paper 6. Whiteboards and dry-erase markers 7. Rulers, scales, squares, protractors, and drawing templates 8. CAD software for optional concept visualization 9. Project rubrics and peer-feedback forms 10. Cameras or mobile devices for documentation **Instructional Methods:** 1. Direct instruction and focused mini-lessons 2. Teacher modeling of ideation strategies	**Extensions:** 1. Conduct a patent search and compare similar inventions. 2. Develop concepts for users with different physical or accessibility needs. 3. Generate a sustainable redesign using recycled or renewable materials. 4. Develop a preliminary CAD model of the selected concept. 5. Conduct additional interviews with potential users or industry professionals. 6. Compare concepts using cost, manufacturability, environmental impact, and marketability.

3. Individual brainstorming and reflection 4. Cooperative learning and team ideation 5. Think-pair-share and brainwriting 6. Visual thinking and sketching demonstrations 7. Project-based learning 8. Guided inquiry and problem-solving 9. User-centered design discussions	**Remediation:** 1. Review the purpose and sequence of the ideation process. 2. Provide examples of effective brainstorming and concept sketches. 3. Use structured brainstorming prompts and question cards. 4. Begin with teacher-guided brainstorming before independent work. 5. Pair students with supportive peers for collaborative idea generation. 6. Conduct small-group or individual design conferences. 7. Provide frequent feedback and checkpoints.

Unit: Design Project (Prototype step) - Concept Visualization and Prototyping	**Time:** 2 weeks

Academic Standards:

3.5.9-12.X - Implement the best possible solution to a design using an explicit process.

3.5.9-12.AA - Safely apply an appropriate range of making skills to a design thinking process.

3.5.9-12.PP - Demonstrate the use of conceptual, graphical, virtual, mathematical, and physical modeling to identify conflicting considerations before the entire system is developed and to aid in design decision making.

3.5.9-12.Q - Implement and critique principles, elements, and factors of design.

Essential Content/Objective: At the end of the unit, students will be able to:

1. Explain the purpose of concept visualization and prototyping within the design-thinking process.
2. Translate written design ideas into sketches, technical drawings, CAD models, and physical prototypes.
3. Create rough, refined, isometric, orthographic, and scaled drawings.
4. Apply appropriate design principles, elements, dimensions, and annotations to communicate a concept.
5. Select appropriate materials, tools, machines, and fabrication methods for a prototype.
6. Safely and accurately use manual tools, digital fabrication equipment, and prototyping materials.
7. Construct a physical prototype that demonstrates the product's form, scale, function, or user interaction.
8. Identify manufacturing and assembly challenges during prototype construction.
9. Document design decisions, construction processes, revisions, and lessons learned.
10. Use feedback and evidence to improve the prototype.

Core Student Activities: Students will complete/participate in the following:

1. Produce thumbnail sketches and alternative concept drawings.

Assessment:

1. Engineering notebook or portfolio documentation
2. Participation in design reviews and peer critiques
3. Oral presentation and prototype demonstration
4. Student self-assessment and reflection
5. Teacher observation and project rubric

2. Develop isometric and orthographic drawings with dimensions.
3. Create a scaled CAD model using available design software.
4. Prepare a materials list, cutting list, and construction plan.
5. Construct low-fidelity models using materials such as paper, cardboard, foam, or clay.
6. Build a more refined physical prototype using appropriate materials and fabrication processes.
7. Use hand tools, shop machines, laser cutters, CNC equipment, waterjet equipment, or 3-D printers as appropriate.
8. Document progress through photographs, sketches, CAD screenshots, and portfolio entries.
9. Participate in design reviews and peer critiques.
10. Identify construction problems and make iterative improvements.
11. Present the completed prototype and explain how it addresses the design problem.

Materials and Resources:

1. Design briefs, criteria, constraints, and project rubrics
2. Engineering notebooks or design portfolios
3. Sketch paper, graph paper, tracing paper, and templates
4. Pencils, colored pencils, markers, and erasers
5. Rulers, scales, squares, protractors, compasses, and calipers
6. Computers or laptops with CAD software
7. Autodesk Fusion, AutoCAD, or comparable design software
8. Cardboard, foam board, paper, clay, wood, acrylic, and recyclable materials
9. Hot glue, adhesives, fasteners, tape, and joining materials
10. Utility knives, craft knives, saws, drills, sanders, and other hand tools
11. 3-D printers, laser cutters, CNC machines, and waterjet equipment
12. Personal protective equipment
13. Cameras or mobile devices for documentation

Instructional Methods:

1. Direct instruction and mini-lessons

Extensions:

1. Produce multiple prototype versions for comparison.
2. Develop an animated or moving CAD assembly.
3. Calculate material costs, production time, and waste.
4. Seek feedback from industry professionals or community partners.
5. Redesign the prototype for mass production or customization.

Remediation:

1. Review the purpose and sequence of the prototyping process.
2. Provide examples of successful sketches, CAD models, and prototypes.

2. Teacher modeling of sketching and visualization techniques 3. CAD demonstrations and guided practice 4. Hands-on laboratory work 5. Project-based learning 6. Guided inquiry and iterative problem-solving 7. Individual and collaborative design work 8. Peer critique and design review 9. Demonstration of material-processing and assembly methods 10. Learning stations for tools, materials, CAD, and fabrication equipment 11. Formative questioning and progress checks	3. Use guided sketching exercises and drawing templates. 4. Reteach scale, measurement, dimensioning, and drawing conventions. 5. Break the prototype into smaller components and sequential tasks. 6. Offer step-by-step CAD tutorials and partially completed model files.

Unit: Design Project (Test step)	**Time:** 2 weeks

Academic Standards:

3.5.9-12.I (ETS) - Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

3.5.9-12.J - Synthesize data and analyze trends to make decisions about technological products, systems, or processes.

3.5.9-12.QQ - Implement quality control as a planned process to ensure that a product, service, or system meets established criteria.

3.5.9-12.W - Optimize a design by addressing desired qualities within criteria and constraints while considering trade-offs.

Essential Content/Objective: At the end of the unit, students will be able to:

1. Develop a testing plan based on established design criteria, constraints, and user needs.
2. Create measurable procedures for evaluating product function, usability, safety, durability, and quality.
3. Gather qualitative and quantitative feedback from users.
4. Accurately record observations, measurements, survey responses, and test results.
5. Analyze data and identify trends, defects, and areas for improvement.
6. Compare test results with the original design specifications.
7. Use evidence to make informed design revisions.
8. Retest the modified prototype to determine whether its performance improved.
9. Communicate testing results and design recommendations.

Core Student Activities: Students will complete/participate in the following:

1. Review the project's design criteria and constraints.
2. Develop a product-testing plan, checklist, and schedule.
3. Identify variables, performance measures, and acceptable results.
4. Conduct safety, function, durability, and usability tests.
5. Observe classmates or end users interacting with the prototype.

Assessment:

1. Final presentation and project rubric
2. Student self-assessment and peer evaluation
3. Weekly progress portfolio write-up

6. Create and administer user surveys or interviews. 7. Record test data, observations, photographs, and video evidence. 8. Organize data using tables, charts, or spreadsheets. 9. Identify product failures and troubleshoot their causes. 10. Modify the prototype based on test results and user feedback. 11. Retest the revised prototype and compare results. 12. Prepare a testing report and present recommended improvements.	
Materials and Resources: 1. Student prototypes and design specifications 2. Testing-plan templates and checklists 3. Project rubrics and evaluation criteria 4. User surveys and interview forms **Instructional Methods:** 1. Direct instruction and mini-lessons 2. Teacher modeling of testing procedures 3. Peer-to-peer feedback 4. User-centered observation and interviews 5. Formative questioning and class discussion	**Extensions:** 1. Invite community members or industry professionals to serve as end users. 2. Compare the product with an existing commercial product. 3. Conduct extended durability or accelerated-life testing. 4. Create a video demonstrating the testing and redesign process. **Remediation:** 1. Review the purposes and steps of product testing. 2. Model one complete test before independent work begins. 3. Break the testing process into smaller, sequential tasks. 4. Use teacher-guided or small-group testing. 5. Provide individual feedback and opportunities to revise and retest.

Unit: Design Project (Produce step)	**Time:** 2 weeks

Academic Standards:

3.5.9-12.M - Develop a device or system for the marketplace.

3.5.9-12.X - Implement the best possible solution to a design using an explicit process.

3.5.9-12.QQ - Implement quality control as a planned process to ensure that a product, service, or system meets established criteria.

3.5.9-12.B - Critically assess and evaluate a technology that minimizes resource use and resulting waste to achieve a goal.

Essential Content/Objective: At the end of the unit, students will be able to:

1. Explain how the production phase transforms a tested design into a finished product.
2. Interpret final drawings, CAD models, dimensions, specifications, criteria, and constraints.
3. Develop a production plan that identifies materials, tools, equipment, procedures, timelines, and quality-control checkpoints.
4. Select durable, sustainable, and appropriate materials based on function, safety, availability, and cost.
5. Safely and accurately operate appropriate hand tools, machines, and digital fabrication equipment.
6. Apply measuring, layout, cutting, shaping, forming, joining, assembly, and finishing techniques.
7. Manufacture components within established dimensions and tolerances.
8. Implement quality-control procedures throughout production.
9. Troubleshoot manufacturing and assembly problems.
10. Make evidence-based adjustments when components or processes fail to meet specifications.
11. Complete a functional final product that addresses the identified user need.
12. Document and communicate the production process and final results.

Assessment:

1. Quality-control checklist and inspection records
2. Engineering notebook or portfolio documentation
3. Final product demonstration and presentation
4. Teacher observation and project rubric
5. Student self-assessment and peer evaluation

Core Student Activities: Students will complete/participate in the following: 1. Conduct a final design review and establish a design freeze a. Finalize working drawings, CAD files, dimensions, tolerances, and specifications. 2. Develop a step-by-step manufacturing process plan a. Cutting list, and production schedule b. Required tools & machines c. Safety Procedures d. Personal protective equipment 3. Manufacturing of product a. Select and organize materials b. Measure and lay out product components. c. Cut, shape, form, machine, or digitally fabricate components. d. Assemble components using appropriate adhesives, fasteners, joints, or manufacturing processes. e. Apply appropriate surface treatments, finishes, labels, or protective coatings. 4. Conduct quality-control inspections during each stage of production. a. Record dimensions, tolerances, defects, adjustments, and completed checkpoints. b. Troubleshoot manufacturing errors and rework components when necessary. c. Document the production process using photographs, videos, drawings, and portfolio entries. 5. Conduct a final product review/presentation a. Compare the finished product with the original criteria and constraints. b. Present and demonstrate the completed product. c. Complete a self-evaluation and participate in peer critique.	
Materials and Resources: 1. Final design brief, criteria, constraints, and project rubric 2. Working drawings, CAD models, and technical specifications	**Extensions:** 1. Design and manufacture jigs, fixtures, or templates to improve accuracy.

3. Quality-control checklists and inspection tools
4. Engineering notebooks or design portfolios
5. Computers or laptops with CAD and manufacturing software
6. Project-specific construction materials
7. CNC equipment, Hand tools, and power tools
8. Personal protective equipment
9. Cameras or mobile devices for documentation

Instructional Methods:

1. Direct instruction and focused mini-lessons
2. Teacher modeling of manufacturing processes
3. Tool and machine safety demonstrations
4. Guided practice with tools, machines, and materials
5. Individual and collaborative problem-solving

2. Develop CNC toolpaths or automated manufacturing procedures.
3. Redesign the production process to reduce environmental impact.
4. Create packaging, labeling, and shipping materials.
5. Develop assembly instructions, a user manual, or maintenance guide.
6. Develop a plan for product repair, reuse, recycling, or end-of-life disposal.

Remediation:

1. Review the purpose and sequence of the production process.
2. Break the manufacturing process into smaller, sequential tasks.
3. Provide visual examples of completed drawings, process plans, and products.
4. Provide additional practice using tools, machines, and materials.
5. Schedule frequent teacher checkpoints before students proceed to the next production stage.
6. Provide extended time for fabrication, assembly, and revision.
7. Provide opportunities to repair, remake, or revise components before final assessment.