Curriculum & Instruction

SUMMIT PUBLIC SCHOOLS

Content Area: Technology Education
Course: Advanced CAD
Grade(s): 8

Course Overview

Prerequisite Course Required: Intro to CAD (6th/7th Cycle Class)

This course is a comprehensive, 12-week introduction to the modern innovation pipeline, designed to transition 8th-grade students from simple block modeling to professional-level parametric design and digital fabrication. The curriculum focuses on developing technical proficiency in industry-standard CAD software (Autodesk Fusion 360) and applying that knowledge through hands-on fabrication projects.

Students will transition from TinkerCAD Mesh modeling techniques to Solid modeling techniques used in Fusion 360, all while exploring each program's advantages and disadvantages. Through project-based learning and guided exploration, students will develop dimensioning and spatial reasoning skills to create, manipulate, and refine 3D models, while also learning manufacturing technique limitations.

Each project is designed to reinforce specific modeling techniques and incorporate student creativity in their design solutions. Techniques include: Extrusion, Revolve, Sweep, Lofts, as well as edge modifiers including Fillet and Chamfer.

Beyond technical commands, this course is fundamentally about fostering design thinking and critical problem-solving. Students are encouraged to embrace failure as a crucial part of learning; a failed print or cut is an opportunity to analyze what went wrong in the digital file, troubleshoot the cause, and implement a refined solution. This process strengthens analytical skills and develops the resilience needed for real-world engineering and product development. Furthermore, the course encourages collaborative design, utilizing the software's sharing capabilities to critique and improve peer designs, mirroring a professional studio environment.

New Jersey State Learning Standards

Summit Public Schools curriculum aligns with the New Jersey Student Learning Standards.

Computer Science and Design Thinking Standards:

- **8.1.8.AP.4:** Select and combine control structures for a specific application based upon performance and readability, and identify trade-offs to justify the choice.
- **8.1.8.AP.5:** Decompose problems into smaller components through systematic analysis, using

constructs such as procedures, modules, and/or objects.
- **8.1.8.AP.6:** Debug errors in an algorithm or program that includes sequences and simple loops.
- **8.1.8.AP.7:** Collaboratively design and develop programs and artifacts for broad audiences by incorporating feedback from users.
- **8.1.8.AP.9:** Collaboratively document and present design decisions in the development of complex programs.
- **8.1.8.CT.1:** Identify complex, interdisciplinary, real-world problems that can be solved computationally.
- **8.1.8.DA.1:** Organize and transform data to make it easier to understand and analyze.
- **8.2.8.ED.1:** Design a product or system to satisfy a need, want, or problem.
- **8.2.8.ED.2:** Analyze the trade-offs between competing criteria and constraints during the design process.
- **8.2.8.ETW.3:** Analyze the design of a product that negatively impacts the environment or society and develop possible solutions to lessen its impact.

Interdisciplinary Standards:

- **MS-ETS1-1:** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- **MS-ETS1-2:** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- **MS-ETS1-3:** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- **MS-ETS1-4:** Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.
- **6.3.8.CivicsPR.4:** Analyze the role of innovation and entrepreneurship in the development of new economic opportunities and social benefits.
- **6.3.8.EconET.1:** Using quantitative data, evaluate the opportunity cost of a proposed economic action, and take a position and support it (e.g., healthcare, education, transportation).
- **6.3.8.EconET.2:** Assess the impact of government incentives and disincentives on the economy (e.g., patents, protection of private property, consumer protection laws).
- **6.3.8.EconET.3:** Evaluate the impact of technological changes on the economy and the environment.
- **6.3.8.GeoHE.1:** Analyze the ways in which human-environment interactions have shaped the development of regions and societies.
- **6.3.8.GeoPP.1:** Analyze how the availability of resources (e.g., natural, human, capital) influences economic development and the quality of life in different regions.
- **6.3.8.GeoPP.2:** Evaluate the effectiveness of different strategies for managing the use of natural resources in local, regional, and global contexts.
- **6.3.8.GeoSV.1:** Analyze the impact of human activities on the environment and evaluate the effectiveness of government policies and individual actions in addressing environmental changes.
- **MP.1:** Make sense of problems and persevere in solving them.
- **MP.2:** Reason abstractly and quantitatively.
- **MP.3:** Construct viable arguments and critique the reasoning of others.
- **MP.4:** Model with mathematics.

- **MP.5:** Use appropriate tools strategically.
- **MP.6:** Attend to precision.
- **MP.7:** Look for and make use of structure.
- **1.5.8.Cn10a:** Synthesize and relate knowledge and personal experiences to create products.
- **1.5.8.Cn10b:** Employ a variety of research methods to inform the development of original media artworks about global issues, including climate change.
- **1.5.8.Cn11a:** Analyze and contrast how art forms are used to represent, establish, reinforce and reflect group identity and culture.
- **1.5.8.Cr1a:** Generate a variety of ideas, goals and solutions for media artworks using creative processes such as sketching, brainstorming, improvising, and prototyping with increased proficiency, divergent thinking, and opportunity for student choice.
- **1.5.8.Cr2a:** Organize and design artistic ideas for media arts productions.
- **1.5.8.Cr2b:** Critique plans, prototypes and production processes considering purposeful and expressive intent.
- **1.5.8.Cr3a:** Use criteria to examine, reflect on and plan revisions for artworks based on artistic criteria, self-reflection and the feedback of others.
- **1.5.8.Pr5a:** Develop and refine techniques and models or steps needed to create products.
- **1.5.8.Re7a:** Perceive and analyze products.
- **1.5.8.Re8a:** Examine and interpret artistic expression and intent in artworks by considering the relationships among the elements of art, principles of design, and context.
- **RI.MF.8.6:** Evaluate the choices made (by the authors, directors, or actors) when presenting an idea in different mediums and the advantages and disadvantages of using different mediums or formats (e.g., visually, quantitatively) to address a question or solve a problem.
- **W.WP.8.4:** With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well the purpose and audience have been addressed.
- **W.RW.8.7:** Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.
- **SL.PE.8.1:** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.
- **SL.UM.8.5:** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.

Career Readiness, Life Literacies and Key Skills Standards:

- **9.4.8.CI.1:** Gathering and evaluating knowledge and information from a variety of sources, including global perspectives, fosters creativity and innovative thinking.
- **9.4.8.CT.1:** Multiple solutions exist to solve a problem.
- **9.4.8.CT.2:** An essential aspect of problem solving is being able to self-reflect on why possible solutions for solving problems were or were not successful.
- **9.4.8.IML.12:** Use relevant tools to produce, publish, and deliver information supported with evidence for an authentic audience.
- **9.4.8.IML.13:** Identify the impact of the creator on the content, production, and delivery of information (e.g., 8.2.8.ED.1).
- **9.4.8.TL.2:** Gather data and digitally represent information to communicate a real-world problem or issue.

Career Ready Practices (list if relevant)

CRP 1. Act as a responsible and contributing citizen and employee.
CRP 2. Apply appropriate academic and technical skills.
CRP 3. Attend to personal health and financial well-being.
CRP 4. Communicate clearly and effectively and with reason.
CRP 5. Consider the environmental, social and economic impacts of decisions.
CRP 6. Demonstrate creativity and innovation.
CRP 7. Employ valid and reliable research strategies.
CRP 8. Utilize critical thinking to make sense of problems and persevere in solving them.
CRP 9. Model integrity, ethical leadership and effective management.
CRP 10. Plan education and career paths aligned to personal goals.
CRP 11. Use technology to enhance productivity.
CRP 12. Work productively in teams while using cultural global competence.

New Jersey Curriculum Mandates: (list only relevant ones)

This curriculum integrates lessons that address the following interdisciplinary New Jersey Curriculum Mandates:

- Diversity and Inclusion (Grades K - 12)
- Climate Change Education (Grades K - 12)

Learning Objectives

Learning objectives are clear, specific statements that define what students should know, understand, and be able to do by the end of a lesson or course.

Students will be able to:

- Articulate fundamental design principles and their importance.
- Identify the core differences between block and parametric CAD modeling.
- Navigate the **Fusion 360** interface and create basic 2D sketches and 3D extrusions.
- Apply foundational mathematical concepts and independent problem-solving strategies from **TinkerCAD** to effectively use **Fusion 360** for more advanced modeling tasks.
- Create precise 2D sketches using constraints and dimensions.
- Apply advanced 3D modeling features such as Boolean operations, fillets, and chamfers.
- Design and assemble multiple parts within **Fusion 360**.
- Prepare and execute their first 3D print, understanding basic slicing parameters and safety.
- Differentiate between laser cutting and engraving processes.
- Prepare 2D designs for laser fabrication using appropriate software and export formats.
- Understand and apply basic laser parameters (speed, power) for different materials.
- Safely operate a laser engraver to produce physical objects.
- Apply advanced modeling techniques (e.g., surface modeling basics, helical curves) to create complex designs.
- Analyze and apply Design for Manufacturing (DFM) principles for both 3D printing and laser engraving.
- Identify and troubleshoot common fabrication issues and iterate on designs to improve outcomes.
- Define a design problem and develop a comprehensive project plan.
- Apply all learned CAD modeling and fabrication skills to create a functional or aesthetic capstone project.

- Effectively present their design process, challenges, and final fabricated product to an audience.

Units of Study

Units of study are organized collections of lessons and learning experiences focused on a specific topic and set of skills within a course. Each unit is guided by a set of essential questions.

Unit 1: Foundations of CAD and Transition (10 Days)

- How does understanding basic design principles help us create better products?
- What are the key differences between block modeling (TinkerCAD) and parametric modeling (Fusion 360)?
- Why is it important to move from simpler CAD tools to more advanced ones?
- How do mathematical concepts and independent problem-solving skills learned in TinkerCAD translate and evolve when using a more complex CAD program like Fusion 360?

Unit 2: Modeling and First Print (20 Days)

- How do precise sketches and constraints improve the quality and accuracy of a 3D model?
- What is the process of transforming a digital 3D model into a physical object using a 3D printer?
- How do different modeling features (like Boolean operations, fillets, and chamfers) allow for more complex and refined designs?
- Why is it important to design parts that can be assembled together effectively?

Unit 3: Laser Engraving and 2D Fabrication (10 Days)

- How does laser engraving differ from 3D printing in terms of design and fabrication?
- What considerations are important when designing for laser cutting versus laser engraving?
- How do different materials affect the outcome of laser fabrication?

Unit 4: Advanced Design & Problem Solving (10 Days)

- How can advanced modeling techniques help create more intricate or specialized designs?
- Why is "design for manufacturing" a critical consideration in the design process?
- What are common challenges in 3D printing and laser engraving, and how can they be overcome?
- How does iteration and feedback improve a design?

Unit 5: Capstone Project (10 Days)

- How can the entire design and fabrication process be applied to solve a real-world problem or create an innovative product?
- What are the key steps in taking a project from concept to a finished physical product?
- How does presenting a design and its fabrication process demonstrate comprehensive understanding and critical thinking?

Instructional Resources and Materials

Instructional resources are the information sources teachers utilize to guide their teaching and assessing. Instructional materials are the texts students read or review. The instructional resources and materials may vary in order to meet the learning needs of students.

Required:

- TinkerCAD access (web-based)
- Fusion 360 accounts/access
- Computers with internet access (one per student recommended)

- Projector or Smartboard for demonstrations
- Basic sketching tools (paper, pencils, rulers)
- Slicing software (e.g., Cura, PrusaSlicer) installed on computers
- 3D Printers (FDM type recommended)
- PLA filament (various colors for student projects)
- Basic 3D printing tools (spatula for print removal, snips for support removal, glue stick/adhesion spray if needed)
- Safety glasses
- Laser Engravers (with appropriate safety enclosures)
- Materials for laser cutting/engraving (e.g., plywood, acrylic, cardboard, craft foam, paper, felt)
- Materials for testing and iteration (e.g., various PLA colors, different wood/acrylic scraps)
- Adequate ventilation system for the laser engraver
- Laser-specific safety glasses (if required by machine)
- Cleaning supplies for laser bed and lenses

Recommended:

- Autodesk Fusion 360 Learning Resources
- YouTube Channels
- Design Thinking Resources
- Thingiverse/Printables
- 3D Printing Guides/Books
- Videos on 3D printer calibration and maintenance
- Examples of assembled products
- Laser Engraver Manufacturer's Documentation
- Online Vector Graphics Tutorials
- Material Suppliers' Data Sheets
- Examples of intricate laser-cut and engraved projects
- Videos on laser cutting/engraving safety
- Industry Case Studies
- DFM Checklists/Guidelines
- Design Portfolio Examples
- Guest speakers

Teacher Resources:

- Teacher's **Fusion 360** account
- Prepared lesson plans for TinkerCAD review and **Fusion 360** introduction.
- Pre-designed models for demonstration and guided practice.
- Rubrics
- Access to the internet and projector for live demonstrations.
- Familiarity with slicing software and 3D printer operation, troubleshooting common issues.
- Safety protocols for 3D printer use.
- Access to 3D printer maintenance tools and spare parts.
- Access to laser engraver maintenance and cleaning supplies.

Assessment Strategies

Assessment measures a student's mastery of a course standard and learning objective. Assessment can be used for both instructional purposes and for evaluative purposes. Teachers may choose one or more of the following ideas to assess learners. They may also modify these ideas to make the assessment more responsive to students' interests and needs.

Formative:

- TinkerCAD Design Review
- Fusion 360 Interface Scavenger Hunt
- Basic Sketch & Extrude Check
- Exit Tickets
- Sketch Constraint Challenges
- Feature Application Mini-Projects
- Slicing Parameter Quiz/Discussion
- Assembly Demonstration
- Peer Feedback and Review
- Vector vs. Raster Identification
- Material Property Matching
- Laser Safety Checklist
- Mini-Engraving/Cut Test
- Advanced Feature Application
- DFM Checklist Application
- Troubleshooting Scenario Analysis
- Process Logs
- Class Discussions

Summative:

- Fusion 360 Basic Part Creation
- Concept Comparison Essay/Short Answer
- Multi-Part Assembly Project
- 3D Print Quality Evaluation
- Slicing Software Task
- Laser-Cut/Engraved Project
- Material Properties Report/Presentation
- 2D Design Challenge
- DFM Redesign Project
- Troubleshooting Case Study
- Advanced Modeling Challenge
- Capstone Project Final Submission
- Capstone Project Presentation
- Project Documentation/Portfolio

Benchmark:

- Fusion 360 Basic Tool Proficiency
- Parametric vs. Direct Modeling Comparison
- Complex Sketch Creation
- Feature Integration Challenge
- Slicing Software Setup
- 2D Design for Laser Proficiency
- Laser Parameter Application
- DFM Principle Application
- Troubleshooting Plan Development
- Advanced Modeling Mini-Project

- Detailed Project Plan Submission
- Mid-Project CAD Review

Alternative:

- Design Vocabulary Matching Game
- Show What You Know Video
- Collaborative Whiteboard Design
- How-To Guide Creation
- Design Critique Video
- Role-Play: Client & Designer
- Interactive Model Annotation
- Infographic on Laser Safety
- Laser Material Guide Video
- Design Fix-It Challenge
- Interview with an Expert
- Design for X Presentation
- Troubleshooting Flowchart
- Before & After Design Showcase
- Expert Interview Simulation
- Shark Tank Pitch
- Instructional Video Series
- Interactive Digital Portfolio
- Community Showcase/Exhibition

Suggested Strategies for Modification & Differentiation

Modifications Chart (update for your content area)