

Unit 2: Assembly Design (10 Weeks)

Content Area: **STEM**
Course(s):
Time Period: **Full Year**
Length: **10 Weeks**
Status: **Published**

UNIT RATIONALE

In this unit, students learn methods to physically join parts in an assembly, including mechanical fasteners, adhesives, press fits, and hinges. They learn about different types of fit and how to specify tolerances to achieve desired fits between interacting parts. Students then learn how to assemble parts using CAD and create simple bottom-up assemblies that realistically simulate physical mechanical systems. Assemblies are documented in CAD with assembly drawings. Students apply engineering principles and practices to reverse engineer and improve a consumer product by disassembling and analyzing a product or system to understand and document the visual, functional, and/or structural aspects of its design. Students will also conduct a case study of a common consumer product to identify potential ways to improve the manufacturability and ease of assembly of the product. Students will also use top-down modeling to model the consumer product students have reverse engineered. They will apply the design process again to design and prototype (3D print) an integrated accessory for the reverse engineered product and present the design. Finally, in this unit students investigate a variety of materials through experimentation and are tasked with selecting materials to serve a specific purpose. The types of materials investigated include wood, metals, ceramics, plastics, and composites to identify properties that may impact material selection. Properties investigated can include density, conductivity, strength, flexibility, hardness, and so on. Students learn how to assign specific materials to CAD models and to differentiate between assigning the physical properties of a material to a part and only changing the visual appearance of the part. Students work within a team to imagine the future through research of innovative materials and the redesign of a product using advanced materials. Lastly, students work collaboratively to reverse engineer and troubleshoot a non-working, multi-component mechanical device. Then, team members work together to redesign the device, produce working drawings, and produce new parts to correct the design and manufacture a working physical model.

ESSENTIAL QUESTIONS

1. What are the different types of tolerance and how can I use tolerance to achieve desired fits between interacting parts?
2. What are the different types of joining techniques?
3. What are assembly joints and how can I use them to create assembled product on CAD?
4. How can we appropriately document design intent using exploded views and parts lists?

5. What is reverse engineering?
6. What is visual analysis and how can I use it to better understand a product?
7. What is functional analysis and how can I use it to better understand a product?
8. What is structural analysis and how can I use it to better understand a product?
9. What is the difference between top down and bottom up modeling and what is it advantageous to use each?
10. What are the principles of design for manufacturing and how can they be used to improve products?
11. What are the different properties materials can have and how can they be

STANDARDS

New Jersey Student Learning Standards: 21st Century

CRP.K-12.CRP2.1	Career-ready individuals readily access and use the knowledge and skills acquired through experience and education to be more productive. They make connections between abstract concepts with real-world applications, and they make correct insights about when it is appropriate to apply the use of an academic skill in a workplace situation.
CRP.K-12.CRP4.1	Career-ready individuals communicate thoughts, ideas, and action plans with clarity, whether using written, verbal, and/or visual methods. They communicate in the workplace with clarity and purpose to make maximum use of their own and others' time. They are excellent writers; they master conventions, word choice, and organization, and use effective tone and presentation skills to articulate ideas. They are skilled at interacting with others; they are active listeners and speak clearly and with purpose. Career-ready individuals think about the audience for their communication and prepare accordingly to ensure the desired outcome.
CRP.K-12.CRP6.1	Career-ready individuals regularly think of ideas that solve problems in new and different ways, and they contribute those ideas in a useful and productive manner to improve their organization. They can consider unconventional ideas and suggestions as solutions to issues, tasks or problems, and they discern which ideas and suggestions will add greatest value. They seek new methods, practices, and ideas from a variety of sources and seek to apply those ideas to their own workplace. They take action on their ideas and understand how to bring innovation to an organization.
CRP.K-12.CRP11.1	Career-ready individuals find and maximize the productive value of existing and new technology to accomplish workplace tasks and solve workplace problems. They are flexible and adaptive in acquiring new technology. They are proficient with ubiquitous technology applications. They understand the inherent risks-personal and organizational-of technology applications, and they take actions to prevent or mitigate these risks.
CRP.K-12.CRP12.1	Career-ready individuals positively contribute to every team, whether formal or informal. They apply an awareness of cultural difference to avoid barriers to productive and positive interaction. They find ways to increase the engagement and contribution of all team members. They plan and facilitate effective team meetings.

NEW JERSEY STUDENT LEARNING STANDARDS: CAREER READINESS, LIFE LITERACIES AND KEY SKILLS

TECH.9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a).
TECH.9.4.12.CI.2	Identify career pathways that highlight personal talents, skills, and abilities (e.g., 1.4.12prof.CR2b, 2.2.12.LF.8).
TECH.9.4.12.CI.3	Investigate new challenges and opportunities for personal growth, advancement, and transition (e.g., 2.1.12.PGD.1).

NEW JERSEY STUDENT LEARNING STANDARDS: COMPUTER SCIENCE AND DESIGN THINKING

CS.9-12.8.2.12.ED.2	Create scaled engineering drawings for a new product or system and make modification to increase optimization based on feedback.
CS.9-12.8.2.12.ED.5	Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics).

NEW JERSEY STUDENT LEARNING STANDARDS: Technology

New Jersey Core Curriculum - Grade 9 - Technology

8.1.12.C.1

Develop an innovative solution to a real world problem or issue in collaboration with peers and experts, and present ideas for feedback through social media or in an online community.

8.2.12.A.2

Analyze a current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste.

8.2.12.C.6

Research an existing product, reverse engineer and redesign it to improve form and function.

8.2.12.D.1

Design and create a prototype to solve a real world problem using a design process, identify constraints addressed during the creation of the prototype, identify trade-offs made, and present the solution for peer review.

TECH.8.1.12.C.1	Develop an innovative solution to a real world problem or issue in collaboration with peers and experts, and present ideas for feedback through social media or in an online community.
TECH.8.2.12.A.2	Analyze a current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste.
TECH.8.2.12.C.6	Research an existing product, reverse engineer and redesign it to improve form and function.
TECH.8.2.12.D.1	Design and create a prototype to solve a real world problem using a design process, identify constraints addressed during the creation of the prototype, identify trade-offs

made, and present the solution for peer review.

PRE-ASSESSMENTS

LEGO block assembly with given dimensional criteria and constraints.

INSTRUCTIONAL PLAN

MODULE 1

Activity 2.1.1

Activity 2.1.1: Tolerate This: Students will apply appropriate tolerances to specify the allowable variation, size of individual features, and orientation and location between features of an object. They will then use the mean and standard deviation of a data set to fit it to a normal distribution and use the Empirical Rule to estimate population percentages.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none">- Identify and Apply Types of Tolerances- Define and apply Standard Deviation- Determine types of Interfaces
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	<ul style="list-style-type: none">- Properly setup Model Block and Pins
Formative Assessment (drives instructional decisions)	<ul style="list-style-type: none">- 3D CAD Drawing
Activities and Resources	<ul style="list-style-type: none">- See above

Suggested Modifications

English Language Learners

Adjusted Speech: The teacher changes speech patterns to increase student comprehension. This could include facing the students, paraphrasing, clearly indicating the most important ideas, and speaking more slowly.

Visuals: The teacher uses graphics, pictures, visuals, and manipulatives. This helps ELL students better understand and comprehend the subjects at hand.

Front-Loading Vocabulary: The teacher front loads vocabulary. This means providing students with a list of important vocabulary words they will need to know for a book, lesson, etc. prior to the lesson being taught. Including pictures to go with the vocabulary words is also very beneficial for the students.

Students with Individualized Education Plans/504s

Chunking: The teacher presents information in a way that makes it easy for students to understand and remember. Chunking is based on the presumption that our working memory is easily overloaded by excessive detail. The best way to deliver information is to organize it into meaningful units. Because students with special needs get overloaded easily, chunking is an effective strategy to use with them.

Checking for Understanding: It is important to constantly check for understanding, especially for students who have accommodations. Teachers want to make sure students understand the concepts being covered in a way that makes sense to them.

Extra time: The teacher provides students with special needs extra time to complete work or answer questions. It is important to give students enough time to process their thoughts.

Oral Reading: The teacher will read work orally to students. Class work such as tests and literature circles may need to be read aloud to the student.

Gifted & Talented Strategies

Extensions/Enrichments: Teachers will provide gifted and talented students with extension/enrichment projects. Students will be challenged to further their understanding, to apply acquired knowledge, and/or to produce something in reference to acquired knowledge.

Modify/Change Activities: Teachers will monitor and modify activities to accommodate those students who need to be challenged further. Additional reading, problem-solving, writing, or project work is necessary for those students who are ready to move on at a rate more accelerated than their peers. In this way G & T students are provided the same opportunity for support as special needs students.

Students at Risk of School Failure

Directions or Instructions: Make sure directions and/or instructions are given in limited numbers. Give directions/instructions verbally and in simple written format. Ask students to repeat the instructions or directions to ensure understanding occurs. Check back with the student to ensure he/she hasn't forgotten.

Peer Support: Peers can help build confidence in other student by assisting in peer learning. Many teachers use the 'ask 3 before me' approach. This is fine, however, a student at risk may have to have a specific student or two to ask. Set this up for the student so he/she knows who to ask for clarification before going

to you.

Alternate or Modified Assignments: Always ask yourself, "How can I modify this assignment to ensure the students at risk are able to complete it?" Sometimes you'll simplify the task, reduce the length of the assignment or allow for a different mode of delivery. For instance, many students may hand something in the at-risk student may jot notes and give you the information verbally. Or, it just may be that you will need to assign an alternate assignment.

Increase One to One Time: When other students are working, always touch base with your students at risk and find out if they're on track or needing some additional support. A few minutes here and there will go a long way to intervene as the need presents itself.

Contracts: It helps to have a working contract between you and your students at risk. This helps prioritize the tasks that need to be done and ensure completion happens. Each day write down what needs to be completed, as the tasks are done, provide a checkmark or happy face. The goal of using contracts is to eventually have the student come to you for completion sign-offs

Hands On: As much as possible, think in concrete terms and provide hands-on tasks. This means a child doing math may require a calculator or counters. The child may need to tape record comprehension activities instead of writing them. A child may have to listen to a story being read instead of reading it him/herself.

Tests/Assessments: Tests can be done orally if need be. Break tests down in smaller increments by having a portion of the test in the morning, another portion after lunch and the final part the next day.

Seating: Seat students near a helping peer or with quick access to the teacher. Those with hearing or sight issues need to be close to the instruction which often means near the front.

Activity 2.1.2

Activity 2.1.2: Hold it Together: Students will research an assigned type of joining technique and present their findings to the class. Together, the class will have compiled a database of information about many different joining techniques.

Student Learning Intentions (SLI) WALT: (We are learning to...)

- Identify types of connections between parts

Student Learning Strategies

Journaling
Collaboration
Cooperative Learning

	APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	- Completed Notebook
Formative Assessment (drives instructional decisions)	- Connector Sheet
Activities and Resources	- See Above
Suggested Modifications	- See activity 2.1.1

Activity 2.1.3

Activity 2.1.3: Putting it Together: Students will apply assembly joint constraints to create assembled files in CAD.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none"> - Identify joint types - Use joint types in OnShape - Constrain/Limit joint travel/movement - Insert 3rd Party Parts
Student Learning Strategies	<p>Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions</p>
Success Criteria	- Properly Assembled Selfie Stick
Formative Assessment (drives instructional decisions)	- 3D CAD File
Activities and Resources	- See Above
Suggested Modifications	- See Activity 2.1.1

Activity 2.1.4

Activity 2.1.4: Document the Assembly: Students will document assemblies appropriately by creating exploded multiview drawings with descriptive annotations.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none">- Create an Exploded View- Create BOM Table- Insert above into CAD Drawing
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	<ul style="list-style-type: none">- Successfully annotated CAD Drawing
Formative Assessment (drives instructional decisions)	<ul style="list-style-type: none">- 3D CAD File
Activities and Resources	<ul style="list-style-type: none">- See Above
Suggested Modifications	<ul style="list-style-type: none">- See Activity 2.1.1

MODULE 2

Activity 2.2.1

Activity 2.2.1: What is Reverse Engineering?: Students will closely analyze the inner and outer workings of a video game controller to learn the processes involved in reverse engineering.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none">- Define Reverse Engineering
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Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	- Notebook
Formative Assessment (drives instructional decisions)	- Labeled Handout
Activities and Resources	- See above
Suggested Modifications	- See Activity 2.1.1

Activity 2.2.2

Activity 2.2.2: Visual Analysis: Students will perform a visual analysis of an object of their choosing by describing how the elements and principles of design are at work in the product.

Student Learning Intentions (SLI) WALT: (We are learning to...)	- Define and Perform Visual Analysis
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	- Properly filled out journal questions
Formative Assessment (drives instructional decisions)	- Engineering Notebook
Activities and Resources	- See Above
Suggested Modifications	- See Activity 2.1.1

Activity 2.2.3

Activity 2.2.3: Functional Analysis and the Black Box: Students will perform a functional analysis of an object of their choosing by describing how it works, and describing the system's inputs and outputs.

Student Learning Intentions (SLI) WALT: (We are learning to...)	- Define and Perform Functional Analysis
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	- Properly filled out journal questions
Formative Assessment (drives instructional decisions)	- Engineering Notebook
Activities and Resources	- See Above
Suggested Modifications	- See Activity 2.1.1

Activity 2.2.4

Activity 2.2.4: Structural Analysis and Product Disassembly: Students will perform a structural analysis of an object of their choosing by taking it apart and noting details of each component through a Product Disassembly Chart. Students will create 3D CAD models of each component of their product.

Student Learning Intentions (SLI) WALT: (We are learning to...)	- Define and Perform Structural Analysis - Re-create part from product
Student Learning Strategies	Journaling

	<ul style="list-style-type: none"> Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	<ul style="list-style-type: none"> - Proper Tool Usage - Proper Disassembly of Product
Formative Assessment (drives instructional decisions)	<ul style="list-style-type: none"> - Properly reproduced 3D Part with Drawing
Activities and Resources	<ul style="list-style-type: none"> - See Above
Suggested Modifications	<ul style="list-style-type: none"> - See Activity 2.1.1

Activity 2.2.5

Activity 2.2.5: CAD Design Tools: Students will apply more advanced CAD commands, such as the sweep, revolve and construction features, to 3D model a simplified version of a water heating tube for a coffee maker, which students have been looking at as an example during each step of the reverse engineering process.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none"> - Define and Use Sweep and Revolve functions in OnShape - Creating and using planes
Student Learning Strategies	<ul style="list-style-type: none"> Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	<ul style="list-style-type: none"> - Using revolve and sweep
Formative Assessment (drives instructional decisions)	<ul style="list-style-type: none"> - 3D CAD File
Activities and Resources	<ul style="list-style-type: none"> - See Above
Suggested Modifications	<ul style="list-style-type: none"> - See Activity 2.1.1

Activity 2.2.6

Activity 2.2.6: Top down or bottom up?: Each member of a group will be assigned a subassembly, which they will create using top down modeling. Students will create assembly drawings for their subassemblies, including multiview drawings, exploded views, parts lists, and title blocks. Then, the group will assemble their subassemblies to create their full assembly model, using bottom up modeling.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none">- Define Top Down and Bottom Up methods of design- Define Sub-Assembly- Inserting and Sharing Assemblies
Student Learning Strategies	<ul style="list-style-type: none">JournalingCollaborationCooperative LearningAPB Approach (Activities, Projects, Problems)Class Discussions
Success Criteria	<ul style="list-style-type: none">- Deconstructing carabiner pen- Re-Assembly of carabiner pen in 3D
Formative Assessment (drives instructional decisions)	<ul style="list-style-type: none">- 3D CAD File
Activities and Resources	<ul style="list-style-type: none">- See Above
Suggested Modifications	<ul style="list-style-type: none">- See Activity 2.1.1

Activity 2.2.7

Activity 2.2.7: Design for Manufacturability and Assembly: Students will apply the principles of design for manufacturability and assembly of mechanical products by analyzing a jaw style staple remover, conducting a functional analysis, product disassembly and calculating the complexity factor. Students will analyze manufacturing processes to brainstorm what parts of the stapler remover could be adapted to improve its manufacturability, taking DFMA guidelines into account.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none"> - Define and Calculate Complexity Factor - Modify existing design
Student Learning Strategies	<ul style="list-style-type: none"> Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	<ul style="list-style-type: none"> - Sketches - Disassembly of Staple Remover
Formative Assessment (drives instructional decisions)	<ul style="list-style-type: none"> - Engineering Notebook
Activities and Resources	<ul style="list-style-type: none"> - See Above
Suggested Modifications	<ul style="list-style-type: none"> - See Activity 2.1.1

MODULE 3

Activity 2.3.1

Activity 2.3.1: Material Properties: Students explore material properties, starting with mass, weight, volume and density and then getting into more complicated properties, such as chemical, magnetic, thermal and mechanical properties. Students will conduct non-destructive tests (hardness, flexure, conductivity) on different material types to investigate material properties.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none"> - Determine specific properties of a material - Use graduated cylinder - Use voltmeter
Student Learning Strategies	<ul style="list-style-type: none"> Journaling Collaboration Cooperative Learning

	APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	- Proper use of mathematical calculations
Formative Assessment (drives instructional decisions)	- Engineering Notebook
Activities and Resources	- See Above
Suggested Modifications	- See Activity 2.1.1

Activity 2.3.2

Activity 2.3.2: Evaluating Materials: Students will select and justify the use of materials for prototyping and manufacturing products. Students will design a Martian Habitat, focusing on justifying why they chose certain materials to use for different parts of the habitat.

Student Learning Intentions (SLI) WALT: (We are learning to...)	- Determine specific material uses
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions Game
Success Criteria	- Properly filled out worksheet
Formative Assessment (drives instructional decisions)	- Game
Activities and Resources	- See Above
Suggested Modifications	- See Activity 2.1.1

Activity 2.3.3

Activity 2.3.3: Students will change the material and appearance of their CAD models. Students will create new materials in CAD that they can assign properties to. Students will run interference testing on CAD assemblies to observe and fix overlap among part files in an assembly.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none">- Apply Materials and Appearances to Parts in OnShape- Create new material in OnSHape- Apply Interference Testing
Student Learning Strategies	<ul style="list-style-type: none">JournalingCollaborationCooperative LearningAPB Approach (Activities, Projects, Problems)Class Discussions
Success Criteria	<ul style="list-style-type: none">- Material and Appearance properly applied to part- 3D Part/Assembly interference fixed/modified
Formative Assessment (drives instructional decisions)	<ul style="list-style-type: none">- 3D CAD File
Activities and Resources	<ul style="list-style-type: none">- See Above
Suggested Modifications	<ul style="list-style-type: none">- See Activity 2.1.1

REFLECTIONS

INTERDISCIPLINARY CONNECTIONS: NEW JERSEY STUDENT LEARNING STANDARDS FOR ELA, SOCIAL STUDIES, SCIENCE AND/OR MATHEMATICS

CCSS.Math.Content.HSG-MG.A.1	Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
CCSS.Math.Content.HSG-MG.A.2	Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).

SCI.HS-ETS1-4

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.

CS.9-12.8.1.12.CS.2

Model interactions between application software, system software, and hardware.

CS.9-12.8.2.12.ED.3

Evaluate several models of the same type of product and make recommendations for a new design based on a cost benefit analysis.