**FREEHOLD REGIONAL HIGH SCHOOL DISTRICT**

**OFFICE OF CURRICULUM AND INSTRUCTION**

**SCIENCE AND ENGINEERING**

# INTRODUCTION TO COMPUTER PROGRAMMING AND ENGINEERING DESIGN

Grade Level: 9

Credits: 5

**BOARD OF EDUCATION ADOPTION DATE:**

**AUGUST 25, 2014**

# FREEHOLD REGIONAL HIGH SCHOOL DISTRICT




## Curriculum Writing Committee

Mr. Erik Levin

## Supervisor

Dr. Adam Angelozzi

| INTRODUCTION TO COMPUTER PROGRAMMING AND ENGINEERING DESIGN |
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| COURSE PHILOSOPHY |
| *Computer Programming and Engineering Design* provides a foundation in the theory and methods of computer programming in a modern, object-oriented language, and a foundation in the methods of engineering design and structure. It focuses on developing the problem solving and technical communication skills necessary for successful growth in science, mathematics, and engineering. Students will use and create original computer programs to find solutions to common problems. Students will practice problem solving skills, develop their own solutions to problems, practice technical communications skills, and examine particular specialized communication techniques. |
| COURSE DESCRIPTION |
| In *Computer Programming and Engineering Design,* students implement a variety of software applications designed to highlight basic tools and concepts including number representations, loops, conditions, the procedural model of programming, and basic object-oriented concepts. The applications are selected from various relevant math, science, and engineering topics. Students will also examine standard methods of representing engineered structures, methods of measurement, and will produce engineering drawings and CAD models of engineered parts and structures. |

| COURSE SUMMARY | |
| --- | --- |
| COURSE GOALS | |
| CG1: Students will be able to transfer their understanding of software structure and techniques to analyze a problem and implement a computer-based solution.<br>CG2: Students will be able to transfer their understanding of design principles and representations to analyze, revise, and produce designs for simple mechanical elements and systems. | |
| COURSE ENDURING UNDERSTANDINGS | COURSE ESSENTIAL QUESTIONS |
| CEU1: Common themes guide the design process across many different contexts. | CEQ1a: What techniques are common across all areas of design?<br><br>CEQ1b: Are there standard ways to move from a problem specification to a design for a solution? |

| UNIT GOALS & PACING | | |
|---|---|---|
| UNIT TITLE | UNIT GOALS | RECOMMENDED DURATION |
| Unit 1: Introduction and Structure of Software | Students will be able to build and modify simple applications to meet a specified goal by selecting appropriate control structures, using standard data types and operations, and using appropriate interfaces to the programming environment. | 4 weeks |
| Unit 2: Elementary Data Types and Structures | Students will be able to create effective and efficient programs by selecting the appropriate standard data types or building new data types when necessary. | 5 weeks |
| Unit 3: Procedural Model of Software | Students will be able to effectively solve problems by creating programs that utilize procedural methods, recursive methods, and mathematical methods. | 5 weeks |
| Unit 4: Data Representations | Students will be able to use and build elementary data structures and operations to act upon them. | 6 weeks |
| Unit 5: Elementary Design Tools | LG1: Students will be able to create, analyze, and modify common standard types of engineering drawings for elementary structures.<br>LG2: Students will be able to select the appropriate representations to communicate a physical model or design. | 5 weeks |
| Unit 6: Measurement, Dimensions, and Tolerances | Students will be able to create models by specifying, measuring, and interpreting dimensions for physical structures and specifying appropriate tolerances for dimensions. | 5 weeks |
| Unit 7: Computer Aided Design and Modeling | LG1: Students will be able to design simple parts using a CAD system or 3D modeler.<br>LG2: Students will be able to produce and modify engineering designs by selecting the appropriate tools. | 8 weeks |

**INTRODUCTION TO COMPUTER PROGRAMMING AND ENGINEERING DESIGN**
**UNIT 1: INTRODUCTION AND STRUCTURE OF PROGRAMS** **SUGGESTED DURATION: 4 WEEKS**

| **UNIT OVERVIEW** | | |
|---|---|---|
| UNIT LEARNING GOALS | | |
| Students will be able to build and modify simple applications to meet a specified goal by selecting appropriate control structures, using standard data types and operations, and using appropriate interfaces to the programming environment. | | |
| UNIT LEARNING SCALE | | |
| 4 | In addition to score 3 performances, the student can introduce simple design changes to meet broad goals without close direction. | |
| 3 | The student can build simple applications to a specified design by:<br>• selecting appropriate control structures;<br>• selecting and using the appropriate standard data types and control structures;<br>• using appropriate interfaces and output tools for the programming environment to meet specifications. | |
| 2 | The student can modify elementary example applications and change behavior to meet a specified goal. | |
| 1 | The student needs assistance in order to build or modify elementary applications. | |
| 0 | Even with help, the student is not able to build the majority of applications. | |

| ENDURING UNDERSTANDINGS | ESSENTIAL QUESTIONS |
|---|---|
| EU1: There are underlying themes and structures to modern computer languages and operating systems that influence the structure and interfaces of the software. | EQ1: What influences the design of software? |
| EU2: Computers use representations of abstract concepts. | EQ2a: How does context influence the interpretation of symbols and information?<br>EQ2b: Why are there standard ways of structuring information and indicating context? |

| NJCCCS & COMMON CORE STANDARDS |
|---|
| 8.1.12.F.2 Analyze the capabilities and limitations of current and emerging technological resources and assess their potential to address educational, career, personal, and social needs.<br>8.2.12.G.1 Analyze the interactions among various technologies and collaborate to create a product or system demonstrating their interactivity.<br><br>M.HS.N.Q.2 Define appropriate quantities for the purpose of descriptive modeling.<br>M.HS.F.IF.2 Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.<br>M.HS.F.BF.1 Write a function that describes a relationship between two quantities. |

| COMMON ASSESSMENT | |
|---|---|
| ALIGNMENT | DESCRIPTION |
| LG1<br>EU1, EQ1, EU2, EQ2a, EQ2b<br>N.Q.2, F.IF.2, F.BF.1<br>DOK 4 | Students will construct an application that counts integers at a fixed specification and produces a one dimensional tabular output showing the relation between count values and a function of those values. |

| SUGGESTED STRATEGIES | | |
|---|---|---|
| ACTIVITIES | DECLARATIVE KNOWLEDGE | PROCEDURAL KNOWLEDGE |
| Students will modify a sample pre-defined code template to produce a multiplication table.<br><br>Students may be provided with alternative, less complex tasks as building exercises, or scaffolding may be provided. | Loop, Condition, Scope of Variable, Arithmetic Operations, Output Operation, Declaration of Variables, Typing of Variables<br><br>DOK 1 | • Specify termination and continuance conditions<br>• Demonstrate use of proper syntax<br>• Debug of run time errors<br>• Prove correctness of conditions<br>• Use nested loops<br><br>DOK 3 |
| Students will produce their own application using standard math library tools.<br><br>Students may be provided with alternative, less complex tasks as building exercises, or scaffolding may be provided. | Standard Functions, Function Call, Return Value<br><br>DOK 1 | Utilize a function by understanding the relationship between a function, the return type, and the function value<br><br>DOK 4 |

**INTRODUCTION TO COMPUTER PROGRAMMING AND ENGINEERING DESIGN**
**UNIT 2: ELEMENTARY DATA TYPES AND STRUCTURES** **SUGGESTED DURATION: 5 WEEKS**

<table>
<tr><th colspan="3">UNIT OVERVIEW</th></tr>
<tr><td colspan="3">UNIT LEARNING GOALS</td></tr>
<tr><td colspan="3">Students will be able to create effective and efficient programs by selecting the appropriate standard data types or building new data types when necessary.</td></tr>
<tr><td colspan="3">UNIT LEARNING SCALE</td></tr>
<tr><td>4</td><td colspan="2">In addition to score 3 performances, the student can use his/her understanding of the difference between the representation of data and the data being represented to improve application implementation.</td></tr>
<tr><td>3</td><td colspan="2">The student can:<br>• select and use appropriate numeric types to implement elementary tasks, taking into account limitations and features of the types;<br>• use elementary types to implement more complex data representations to meet a specification;<br>• structure computation to preserve the appropriate type at each point in computation using casts and knowledge of typing rules;<br>• produce properly formatted output with the appropriate precision.</td></tr>
<tr><td>2</td><td colspan="2">The student can implement a solution using specified data types and can use more complex representations when provided.</td></tr>
<tr><td>1</td><td colspan="2">The student can use elementary and complex data types to build an application with assistance.</td></tr>
<tr><td>0</td><td colspan="2">Even with help, the student does not exhibit ability to select or use elementary data types appropriately.</td></tr>
<tr><td colspan="2">ENDURING UNDERSTANDINGS</td><td>ESSENTIAL QUESTIONS</td></tr>
<tr><td colspan="2">EU1: There are standard representations in most computer languages for common types of information and common operations on data.</td><td>EQ1: How does context influence the meaning of a number?</td></tr>
<tr><td colspan="2">EU2: Computer languages have grammatical and syntactic structures that both prescribe and reflect how computational tasks are performed.</td><td>EQ2a: How does grammar relate to structure of a program?<br>EQ2b: Why are the syntax and grammar similar across representations for data and control structures?</td></tr>
<tr><td colspan="3">NJCCCS & COMMON CORE STANDARDS</td></tr>
<tr><td colspan="3">8.2.12.G.1 Analyze the interactions among various technologies and collaborate to create a product or system demonstrating their interactivity.<br><br>M.HS.N.Q.2 Define appropriate quantities for the purpose of descriptive modeling.<br>M.HS.F.IF.2 Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.<br>M.HS.F.BF.1 Write a function that describes a relationship between two quantities.</td></tr>
</table>

<table>
<tr><th colspan="2">COMMON ASSESSMENT</th></tr>
<tr><td>ALIGNMENT</td><td>DESCRIPTION</td></tr>
<tr><td>LG1<br>EU1, EQ1, EU2, EQ2a, EQ2b<br>N.Q.2, F.IF.2, F.BF.1<br>DOK 4</td><td>Students will construct an application to produce computational results, where the computational method involves multiple data types (e.g., integers and real types). Possible specifications include: a table of distances between points with integer coordinates, a table of decimal ratios of integers, or a tool to produce a ratio that is a best approximation to a given real value.</td></tr>
</table>

| **SUGGESTED STRATEGIES** | | |
|---|---|---|
| ACTIVITIES | DECLARATIVE KNOWLEDGE | PROCEDURAL KNOWLEDGE |
| Students will produce an application that accepts an integer input from a user and finds a factor for the input value.<br><br>Students may be provided with alternative, less complex tasks as building exercises, or scaffolding may be provided. | Input Operation, Arithmetic Operations, Output Operation, Typing of Variables<br><br>DOK 1 | • Use standard input tools<br>• Explain the mechanism of translating character input to internal numeric representations<br>• Explain the mechanism of translating internal representations to character output<br>• Use integer operations<br><br>DOK 3 |
| Students will produce an application that will interpret a sequence character input as an integer.<br><br>Students may be provided with alternative, less complex tasks as building exercises, or scaffolding may be provided. | Character Type, Character Set, Delimiter, Escape Character<br><br>DOK 1 | • Use properties of the character set<br>• Interpret delimiter characters<br>• Use the underlying structure of positional notation<br><br>DOK 3 |

**INTRODUCTION TO COMPUTER PROGRAMMING AND ENGINEERING DESIGN**
**UNIT 3: PROCEDURAL MODEL OF SOFTWARE** **SUGGESTED DURATION: 5 WEEKS**

<table>
<tr><th colspan="3">UNIT OVERVIEW</th></tr>
<tr><td colspan="3">UNIT LEARNING GOALS</td></tr>
<tr><td colspan="3">Students will be able to effectively solve problems by creating programs that utilize procedural methods, recursive methods, and mathematical methods.</td></tr>
<tr><td colspan="3">UNIT LEARNING SCALE</td></tr>
<tr><td>4</td><td colspan="2">In addition to score 3 performances, the student can analyze the structure and operation of elementary applications and modify an existing solution to optimize procedural structure.</td></tr>
<tr><td>3</td><td colspan="2">The student can:<br>• outline a solution to a specified problem using pseudo codes, flowcharts, or other appropriate methods;<br>• produce an appropriate functional/procedural structure for an application;<br>• use recursion when appropriate;<br>• properly specify return type and parameters for a function;<br>• properly call the function and appropriately handle the return value;<br>• produce appropriate documentation for the interface to the function allowing for modification or reuse;<br>• justify their solution and method.</td></tr>
<tr><td>2</td><td colspan="2">The student can implement a solution to match a provided outline and implement a recursive solution with guidance.</td></tr>
<tr><td>1</td><td colspan="2">The student needs assistance in order to implement a solution to meet a provided outline.</td></tr>
<tr><td>0</td><td colspan="2">Even with help, the student is not able to outline a solution or implement an application.</td></tr>
<tr><td colspan="2">ENDURING UNDERSTANDINGS</td><td>ESSENTIAL QUESTIONS</td></tr>
<tr><td colspan="2">EU1: Procedural and structured programming ease the process of building solutions by helping to build them in an organized, maintainable, and reusable manner.</td><td>EQ1a: How are functions specified and structured?<br>EQ1b: Why does the software model resemble the mathematical model of a function and how does this help allow for reuse of software?</td></tr>
<tr><td colspan="2">EU2: Recursive methods can be a natural way to structure a solution.</td><td>EQ2a: What is the relation between recursive and non-recursive solutions?<br>EQ2b: How does the selected solution method affect efficiency of the solution?</td></tr>
<tr><td colspan="3">NJCCCS & COMMON CORE STANDARDS</td></tr>
<tr><td colspan="3">8.2.12.G.1 Analyze the interactions among various technologies and collaborate to create a product or system demonstrating their interactivity.<br>8.2.12.F.1 Determine and use the appropriate application of resources in the design, development, and creation of a technological product or system.<br><br>M.HS.N.Q.2 Define appropriate quantities for the purpose of descriptive modeling.<br>M.HS.F.IF.2 Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.<br>M.HS.F.IF.3 Recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers.<br>M.HS.F.BF.1 Write a function that describes a relationship between two quantities.<br>M.HS.F.BF.2 Write arithmetic and geometric sequences both recursively and with an explicit formula, use them to model situations, and translate between the two forms.</td></tr>
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| COMMON ASSESSMENT | |
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| ALIGNMENT | DESCRIPTION |
| LG1<br>EU1, EQ1a, EQ1b, EU2, EQ2a, EQ2b<br>8.2.12.F.1, N.Q.2, F.IF.2, F.IF.3, F.BF.1, F.BF.2<br>DOK3 | Students will produce an application that uses one or more student designed function. The function will produce a return value based on one or more parameters, and will perform a non-trivial, iterative or recursive operation (e.g., compute square root using the Newton-Rapheson method). |

| SUGGESTED STRATEGIES | | |
| --- | --- | --- |
| ACTIVITIES | DECLARATIVE KNOWLEDGE | PROCEDURAL KNOWLEDGE |
| Students will implement Euclid's GCF algorithm as a function with two parameters.<br><br>Students may be provided with alternative, less complex tasks as building exercises, or scaffolding may be provided. | Parameter, Return Value, Common Factor, Number Theory, Divisibility, Relative Prime<br><br>DOK 1 | • Implement a standard mathematical tool as a function suitable for reuse<br>• Use the relationship between division, subtraction, remainders, and modulo<br><br>DOK 3 |
| Students will write an application to find and produce the $n^{th}$ Fibonacci value iteratively and recursively.<br><br>Students may be provided with alternative, less complex tasks as building exercises, or scaffolding may be provided. | Iteration, Recursion, Recurrence, Recursion Relation<br><br>DOK 1 | • Prove termination of a recursive process<br>• Relate the iterative process to the recursive process<br>• Prove the correctness of a function<br>• Understand the respective benefits of recursive and non-recursive iteration<br><br>DOK 4 |

| UNIT OVERVIEW | |
|---|---|
| UNIT LEARNING GOALS | |
| Students will be able to use and build elementary data structures and operations to act upon them. | |
| UNIT LEARNING SCALE | |
| 4 | In addition to score 3 performances, the student can build appropriate operations to operate on a data structure and can illustrate how properties associated with familiar data types can influence the behavior of computer applications which act on these data types. |
| 3 | The student is able to<br>• build a data structure to store specified, nontrivial data;<br>• use an array to store a large data set and operate on it to meet a specification;<br>• design a new data type to meet a specification;<br>• explain the relation between the selected representation and the data being modeled;<br>• output properly formatted elements of the data type. |
| 2 | The student can use provided data structures to solve a problem and can use arrays for simple specified tasks. |
| 1 | The student needs assistance in order to use a provided data structure or array. |
| 0 | Even with help, the student is unable to properly implement or use specified data structures. |

| ENDURING UNDERSTANDINGS | ESSENTIAL QUESTIONS |
|---|---|
| EU1: Standard data structures, such as the array, can be used to address many types of problem. | EQ1a: When do large data sets occur?<br>EQ1b: What are some common applications for the array other than storing large data sets? |
| EU2: New structures and associated functions can be built from standard structures, types, and operations. | EQ2a: How do we design new data types?<br>EQ2b: How do properly designed data types support debugging, maintenance, and reuse of code? |

| NJCCCS & COMMON CORE STANDARDS |
|---|
| 8.2.12.G.1 Analyze the interactions among various technologies and collaborate to create a product or system demonstrating their interactivity.<br>8.2.12.F.1 Determine and use the appropriate application of resources in the design, development, and creation of a technological product or system.<br><br>M.HS.N.Q.2 Define appropriate quantities for the purpose of descriptive modeling. |

| COMMON ASSESSMENT | |
|---|---|
| ALIGNMENT | DESCRIPTION |
| LG1<br>EU1, EQ1a, EQ1b, EU2, EQ2a, EQ2b<br>8.2.12.F.1, N.Q.2<br>DOK 4 | The students will design and implement a structure or object type to represent non-trivial data (e.g., complex number, rational number). The structure will include appropriate operations to initialize, manipulate, modify, and access the data in a type appropriate way. The data type will be used in a type-appropriate task (e.g., finding square roots of a complex number). |

| SUGGESTED STRATEGIES | | |
|---|---|---|
| ACTIVITIES | DECLARATIVE KNOWLEDGE | PROCEDURAL KNOWLEDGE |
| Students will be given the side lengths of a triangle and will implement functions to determine the perimeter, area, and type of triangle.<br><br>Students may be provided with the functions or scaffolding may be provided. | Member Function, Field (Member Variable), Public Access, Private Access<br><br>DOK 1 | • Apply member functions to a structure<br>• Access fields from non-member functions<br><br>DOK 4 |
| Students will produce a list of prime numbers. The project will be structured as a series of functions that look for factors of a candidate using the known primes in the array, generate candidate values, and add the prime numbers to the array.<br><br>Students may be provided with the functions or scaffolding may be provided. | Prime Factor, Divisibility, Array, Type of Array, Boolean Function<br><br>DOK 1 | • Use an array as a parameter<br>• Iterate over elements of an array, using them as potential factors for a number<br><br>DOK 4 |

## UNIT OVERVIEW

### UNIT LEARNING GOALS

LG1: Students will be able to create, analyze, and modify common standard types of engineering drawings for elementary structures.
LG2: Students will be able to select the appropriate representations to communicate a physical model or design.

### UNIT LEARNING SCALE

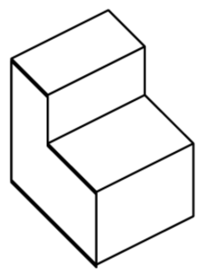
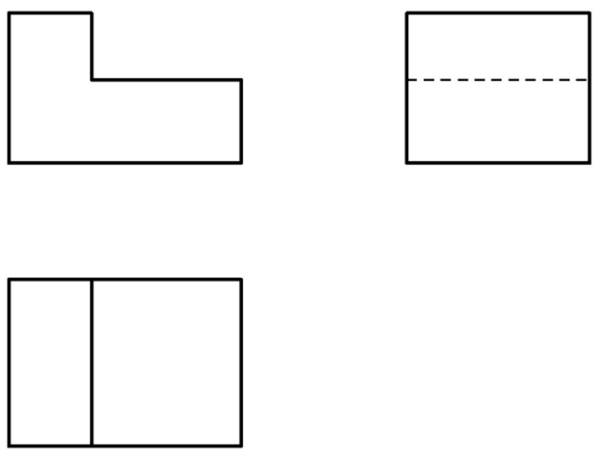
| | |
|---|---|
| 4 | In addition to score 3 performances, the student can make inferences about structures, their purpose, the design considerations behind them, and how these considerations can be expressed by the designer. |
| 3 | The student can:<br>• create orthographic engineering drawings to represent simple objects;<br>• use provided engineering drawings to create a model of the represented object;<br>• create isometric representations of simple object. |
| 2 | The student can identify key elements and features of an object and produce imperfect orthographic and isometric representations. |
| 1 | The student needs assistance in order to interpret features of an object and produce an engineering representation. |
| 0 | Even with help, the student does not exhibit any proficiency identifying and interpreting features or producing an engineering representation of simple objects. |

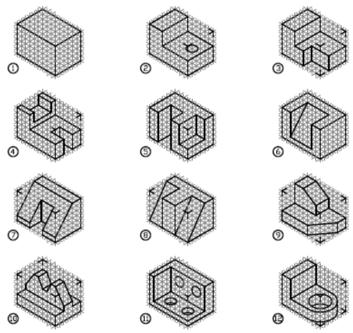
### UNIT LEARNING SCALE

| | |
|---|---|
| 4 | In addition to score 3 performances, the student can revise incorrect representations and clearly communicate the design and structure. |
| 3 | The student can:<br>• select the appropriate representation(s) for a physical object;<br>• expand upon an incomplete representation to fully express physical properties of an object;<br>• produce orthographic representations for simple models with appropriate scaling, proportion, and structure;<br>• maintain proper relationships between features in different views;<br>• create isometric representations of objects from a model or from orthographic representations. |
| 2 | The student can identify key elements that influence the appropriate representation. |
| 1 | The student needs assistance in order to interpret features and appropriate representation. |
| 0 | Even with help, the student does not exhibit any proficiency identifying and interpreting features of an object. |

| ENDURING UNDERSTANDINGS | ESSENTIAL QUESTIONS |
|---|---|
| EU1: Graphical representations are a language and can be an effective method of communicating designs and ideas. | EQ1a: What elements make a sketch or drawing a form of effective communication?<br>EQ1b: What are some properties of good design?<br>EQ1c: When is accuracy sacrificed for clarity? |
| EU2: Orthographic, isometric, and other graphical representations are the standard tools for communicating physical design. | EQ2: How do we select the appropriate representation? |

| NJCCCS & COMMON CORE STANDARDS |
|---|
| 8.2.12.F.1 Determine and use the appropriate application of resources in the design, development, and creation of a technological product or system.<br><br>M.HS.G.MG.1 Use geometric shapes, their measures, and their properties to describe objects.<br>M.HS.G.MG.3 Apply geometric methods to solve design problems.<br>M.HS.G.CO.12 Make formal geometric constructions with a variety of tools and methods.<br>M.HS.G.GMD.4 Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects. |

| **COMMON ASSESSMENT** | |
|---|---|
| ALIGNMENT | DESCRIPTION |
| LG1, LG2<br>EU1, EQ1a, EU2, EQ2a, EQ2b<br>G.MG.1<br>G.CO.12<br>G.GMD.4<br>DOK 3 | Students will produce a suite of at least five-, two-, and three-view engineering drawings of physical models with rectilinear, angled, and circular or arced features. An example of a three-view:<br><br>Shape <br><br>Three-View Engineering Drawing<br> |

| SUGGESTED STRATEGIES | | |
|---|---|---|
| ACTIVITIES | DECLARATIVE KNOWLEDGE | PROCEDURAL KNOWLEDGE |
| Students will complete the missing orthographic view for provided models. One or more views will be provided. Possible shapes include:<br><br>Students with difficulty visualizing features may be provided with models that have features highlighted. Students may be provided with sample drawings for provided objects to reproduce as practice. Students may be permitted drawing aids if needed when sketching. | Orthographic Projection, Scale, Proportion, Front View, Right View, Top View, Two View Drawing, Three View Drawing, Balance, Visible Edge, Hidden Edge, Center Line<br><br>DOK 1 | • Produce orthographic projections in appropriate scale<br>• Produce sketches or drawings with proper balance<br>• Demonstrate appropriate hygiene in product<br>• Identify key features and edges<br>• Utilize the relationship between a three dimensional object and a two dimensional projection<br><br>DOK 3 |
| Students will produce appropriate two or three view orthographic drawings from provided isometric drawings. Students may need to infer hidden features.<br><br>Students with difficulty visualizing features may be provided with models that have features highlighted. Students may be provided with sample drawings for provided objects to reproduce as practice. Students may be permitted drawing aids if needed when sketching. | Isometric, Balance, Visible Edge, Hidden Edge<br><br>DOK 1 | • Use visible features to infer hidden details<br>• Produce orthographic projections in appropriate scale<br>• Identify key features<br>• Utilize the relationship between orthographic projection and isometric projection<br><br>DOK 3 |
| Students will interpret a drawing and produce a physical model of the represented part.<br><br>Students with difficulty visualizing features may be provided with models that have features highlighted. Students may be provided with sample drawings for provided objects to reproduce as practice. Students may be permitted drawing aids if needed when sketching. | Two View Drawing, Three View Drawing, Visible Edge, Hidden Edge<br><br>DOK 1 | Interpret features of a part by synthesizing features from different view<br><br>DOK 3 |

## UNIT OVERVIEW

### UNIT LEARNING GOALS

Students will be able to create models by specifying, measuring, and interpreting dimensions for physical structures and specifying appropriate tolerances for dimensions.

### UNIT LEARNING SCALE

| | |
|---|---|
| 4 | In addition to score 3 performances, the student can make inferences about tolerances from existing parts and specify dimensions and tolerances for parts in a system. |
| 3 | The student can:<br>• use precision measuring tools such as calipers and micrometers to measure features of physical objects;<br>• represent the feature dimensions using appropriate methods;<br>• select appropriate dimensions that are needed to fully specify a part;<br>• specify tolerances appropriately;<br>• use appropriate precision measuring tools to measure features of the object;<br>• interpret tolerance of the measurements;<br>• produce auxiliary views and/or section views, if needed, to fully specify the structure. |
| 2 | The student can specify and interpret dimensions on a drawing incompletely or with conflicting information. |
| 1 | The student needs assistance in order to specify dimensions on a drawing. |
| 0 | Even with help, the student is unable to dimension simple drawings correctly or use precision tools to measure an existing structure. |

| ENDURING UNDERSTANDINGS | ESSENTIAL QUESTIONS |
|---|---|
| EU1: Engineered object can be manufactured to high precision and there are standard methods of specifying dimensions and tolerances. | EQ1a: How do we decide appropriate precision and tolerance for manufacturing a part?<br>EQ1b: How do we specify dimensions and tolerances to maintain acceptable tolerance for all features?<br>EQ1c: How do we detect and avoid conflicting information? |
| EU2: Appropriate tools and techniques can be used to make measurements to a desired precision. | EQ2a: How do we choose which tool to use?<br>EQ2b: How does the measuring tool influence the precision of the measurement? |

### NJCCCS & COMMON CORE STANDARDS

8.2.12.F.1 Determine and use the appropriate application of resources in the design, development, and creation of a technological product or system.

M.HS.N.Q.2 Define appropriate quantities for the purpose of descriptive modeling.
M.HS.N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
M.HS.G.MG.1 Use geometric shapes, their measures, and their properties to describe objects.
M.HS.G.MG.3 Apply geometric methods to solve design problems.

| NJCCCS & COMMON CORE STANDARDS |
|---|
| M.HS.G.CO.12 Make formal geometric constructions with a variety of tools and methods.<br>M.HS.G.GMD.4: Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects. |

| **COMMON ASSESSMENT** | |
|---|---|
| ALIGNMENT | DESCRIPTION |
| LG1<br>EU1, EQ1a, EQ1b, EQ1c<br>EU2, EQ2a, EQ2b<br>8.2.12.F.1, N.Q.2, N.Q.3,<br>G.MG.1, G.GMD.4<br>DOK 3 | The students will produce a properly dimensioned drawing of an engineered object (e.g., vee block). The students will use precision measuring tools to identify dimensions.  |

| **SUGGESTED STRATEGIES** | | |
|---|---|---|
| ACTIVITIES | DECLARATIVE KNOWLEDGE | PROCEDURAL KNOWLEDGE |
| Students will practice using measuring tools by taking measurements of standard parts of known dimension using various tools.<br><br>Students with difficulty visualizing features may be provided with models that have features highlighted. Students may be provided with a selection of measuring tools and aids. Students may be provided with sample drawings for provided objects with required dimensions indicated. Students may be permitted drawing aids if needed when sketching. | Precision, Unit, Accuracy, Tolerance, Vernier Scale, Micrometer, Caliper<br><br>DOK 1 | • Measure features using calipers and micrometers<br>• Specify tolerance of a measured value<br>• Use and explain Vernier scales<br>• Determine the accuracy of a measuring tool based upon its markings and properties<br><br>DOK 2 |
| Students will produce dimensioned orthographic drawings of sample machine parts, and will produce a modified design to meet different dimensional requirements.<br><br>Students with difficulty visualizing features may be provided with models that have features highlighted. Students may be provided with a selection of measuring tools and aids. Students may be provided with sample drawings for provided objects with required dimensions indicated. Students may be permitted drawing aids if needed when sketching. | Secondary Dimension, Accumulated Error, Geometric Tolerancing<br><br>DOK 1 | • Determine dimensions that change as a result of a change in specification<br>• Insure that dimensions are consistent<br>• Identify principal dimensions for a part<br><br>DOK 3 |

| UNIT OVERVIEW | |
|---|---|
| UNIT LEARNING GOALS | |
| LG1: Students will be able to design simple parts using a CAD system or 3D modeler.<br>LG2: Students will be able to produce and modify engineering designs by selecting the appropriate tools. | |
| UNIT LEARNING SCALE | |
| 4 | In addition to score 3 performances, the student can produce a CAD model for a new part to meet specifications. |
| 3 | The student can:<br>• produce a CAD model of simple parts;<br>• specify dimensions appropriately such that the CAD model may be used to produce the part;<br>• use a CAD system to model compatible parts;<br>• build a 3-D model to meet specification using a CAD system. |
| 2 | The student can produce a structurally appropriate CAD model, but possibly with some incorrect features or dimensions. |
| 1 | The student needs assistance in order to produce even a simple CAD model. |
| 0 | Even with help, the student is unable to produce even a simple CAD model. |
| UNIT LEARNING SCALE | |
| 4 | In addition to score 3 performances, the student can select and to use a mix of tools as appropriate, without direction, to produce or modify a model. |
| 3 | The student can:<br>• select and use an appropriate tool to represent a new design based on the complexity of the design and the intended use of the representation;<br>• select and use an appropriate tool to make changes of varying complexity to an existing design;<br>• construct the structure of the object in a 3D capable CAD system;<br>• define parametric relations and specify dimensions for features;<br>• relate advantages and disadvantages of the parametric model used by a CAD system to producing designs by hand. |
| 2 | The student can make appropriate tool selections with guidance to produce a new model or modify an existing model. |
| 1 | The student needs assistance in order to make specified modifications to a model and is not able to select appropriate tools. |
| 0 | Even with help, the student is unable to make appropriate tool selections. |

| ENDURING UNDERSTANDINGS | ESSENTIAL QUESTIONS |
|---|---|
| EU1: Models built in CAD systems can be manipulated to produce many types of standard representations, such as orthographic, isometric, and section views. | EQ1: What are the methodological and conceptual differences between producing drawings by hand and using a CAD tool? |
| EU2: Each production process has its own set of advantages and disadvantages based on the job at hand. | EQ2: What are advantages and disadvantages of various production processes? |

| NJCCCS & COMMON CORE STANDARDS |
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| 8.2.12.B.2 Design and create a prototype for solving a global problem, documenting how the proposed design features affect the feasibility of the prototype through the use of engineering, drawing, and other technical methods of illustration.<br>8.2.12.F.1 Determine and use the appropriate application of resources in the design, development, and creation of a technological product or system;<br>8.2.12.F.3 Select and utilize resources that have been modified by digital tools (e.g., CNC equipment, CAD software) in the creation of a technological product or system.<br><br>M.HS.N.Q.2 Define appropriate quantities for the purpose of descriptive modeling.<br>M.HS.N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.<br>M.HS.G.MG.1 Use geometric shapes, their measures, and their properties to describe objects.<br>M.HS.G.MG.3 Apply geometric methods to solve design problems. |

| **COMMON ASSESSMENT** | |
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| ALIGNMENT | DESCRIPTION |
| LG1, LG2<br>EU1, EQ1, EU2, EQ2<br>8.2.12.F.1, 8.2.12.F.3,<br>N.Q.2, G.MG.1<br>DOK 3 | The students will develop technical multi-view drawings according to third-angle projection principles, and add sectional views, fasteners, auxiliary views, and all details and assemblies using CAD techniques according to industry standards. |

| **SUGGESTED STRATEGIES** | | |
| --- | --- | --- |
| ACTIVITIES | DECLARATIVE KNOWLEDGE | PROCEDURAL KNOWLEDGE |
| Students will learn the basic CAD tools by completing a guided exercise in which they build a sample model.<br><br>Students may be provided with sample drawings for provided objects with required dimensions and constraints indicated. Students may be provided additional guided exercises involving parts previously worked with. Students may obtain CAD models from electronic sources to modify. | CAD, Parametric Model, Projection, Tool, Axes, Coordinate Plane, Constraint<br><br>DOK 1 | • Produce a two dimensional sketch<br>• Use line, arc, and circle tools<br>• Provide constraints for features<br>• Explain a fully constrained sketch<br><br>DOK 2 |

| ACTIVITIES | DECLARATIVE KNOWLEDGE | PROCEDURAL KNOWLEDGE |
|---|---|---|
| Build a CAD model of a physical object previously worked with.<br><br>Students may be provided with sample drawings for provided objects with required dimensions and constraints indicated. Students may be provided additional guided exercises involving parts previously worked with. Students may obtain CAD models from electronic sources to modify. | Sweep, Rotate, Chamfer, Fillet, Extrude, Surface, Solid<br><br>DOK 1 | • Use tools to bring a two dimensional sketch into a three dimensional model<br>• Modify a three dimensional model to specify features such as fillets, chamfers, holes, and drafts<br><br>DOK 3 |
| Modify a CAD model to meet new requirements based on structural or dimensional changes to mating parts in an assembly.<br><br>Students may be provided with sample drawings for provided objects with required dimensions and constraints indicated. Students may be provided additional guided exercises involving parts previously worked with. Students may obtain CAD models from electronic sources to modify. | Constraint, Assembly | • Interpret needed design changes<br>• Insure consistency between a model part and its mate<br>• Interpret existing constraints and determine their appropriateness<br><br>DOK 4 |