DAYTON REGIONAL STEM CENTER

Modeling and Simulation: Survey Course
Grades 10-12

To obtain the curriculum or learn more about training opportunities

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Technical Information and Setup

Minimum Hardware Requirement per workstation
Monitor Keyboard Mouse Headphones Speakers CPU: Processor: Intel core i7, 3.0 GHz RAM: 8 GB Video Card: 1 GB Hard Drive: 500 GB CD-ROM Drive: 8X DVD+/-RW OS: Windows 7 Professional, 64 bit MS Excel, Word, and PowerPoint

Software Minimum Requirements
Microsoft Office Suite: Word, PowerPoint, Excel SolidWorks (student edition) Half Life 2- (Hammer Editor)* Scratch (freeware) Python (freeware)- students will install this as part of Module 4

Minimum Network Requirements
Internet Access (for tutorials, Virtual Trebuchet, streaming videos and research) Student Access to Network Storage (for projects and collaboration) Student Access to the Computer Desktops (for student software download needs)

Student Manipulatives
Tabletop Trebuchet Module (TK3)- Purchasing Details Within Module 1 Materials Section Before Assembly: • Document mass of the arm and counterweight

* There is often confusion about Hammer Editor, Half-Life 2, Source, Steam and Valve. Following is a description meant to guide technical understanding.

- Valve is the corporation that owns the software discussed within this description.
- Steam is an online communications platform hosted by Valve; it allows for digital distribution of software and also offers various community features.
- Source SDK is the software development kit (SDK) in which Half-Life 2 was designed; there are various other engine versions (games) that use Source SDK.
- Half-Life 2 was chosen because Valve's Hammer Editor features can be accessed.
- Hammer Editor is the map creation program within the Source software.

Content Progression

This course is meant to serve as an introduction to the Modeling and Simulation discipline which has diverse applications from training to prototyping. Industry professionals using Modeling and Simulation range from medical responders attempting to improve their response capabilities, manufacturing companies interested in improving quality of production rates or parts, NASCAR's performance interest in designing more aerodynamic vehicles, to aerospace engineers designing new satellites or space systems.

Modeling and Simulation is becoming an increasingly common industry standard as it lessens risks and costs while promoting collaboration and creative problem-solving. The expectation is that course participants will develop a working knowledge of the discipline, mathematical and scientific content as well as 21st century skills such as collaboration, problem-solving, creativity, and technological competency.

Main concepts of Modeling and Simulation include an understanding and application of types of simulation: live, virtual, and constructive, as well as types of modeling: physical, mathematical and process models. Students will also explore computer programming through introductory challenges where they develop a basic source code necessary for the capstone project. It is essential that students routinely employ the Engineering Design Process as they systematically navigate the curricular concepts.

As students work through the learning sequence, they will navigate and address many of the challenges common to this career field including software validation, software verification, and level of fidelity. Validation is the process of determining to what degree a model or simulation represents data, objects, projects or relationships. Verification is the process of determining whether a model or simulation aligns with the developer's theoretical description and specifications. Fidelity refers to the degree the modeled simulation or scenario reflects its true form. Students will spend much time determining the appropriate level of fidelity for the capstone project. This will require students to balance hardware capabilities, allotted time and simulation goals.

Conceptual growth of the individual learner will be monitored throughout the six modules. Student generation of a concept map will occur in Modules One, Five and Six. Additionally, each module relies on student completion of journal entries reflecting the enduring understandings, essential questions, and objectives. These entries will further support a culminating paper submission.

The following chart outlines the content progression of the six modules. Supplied information is also located in the Content Overview section within each module.

Module	Content Overview
Module 1	Module One of this survey course provides an overview and introduction to the field of Modeling and Simulation. Students will be introduced to the discipline, and will complete a concept map to serve as a baseline for measured growth at the end of the semester. Next, students will investigate the types of models and simulations and their potential application in industry. After reviewing course objectives and expectations, students will utilize Microsoft Excel to develop mathematical models of a simple situation. Using their knowledge of the use of Excel, students will interpret data gathered from a physical model of a trebuchet. As a summative assessment, students will validate trebuchet simulation software from VirtualTrebuchet.com, based on the results from the physical model.
Module 2	In Module Two, students will continue the exploration of modeling tools, and will begin conducting research relative to the development of simulations. First, students will explore node theory through an operations research task. They will evaluate process models in a systematic manner and make decisions regarding real-world scenarios. Next, students will investigate the stride length and average walking rate of students in the class. They will utilize Microsoft Excel's capabilities to interpret data and make conclusions. Finally, students will apply their understanding of node theory to the development of an evacuation network blueprint.
Module 3	In Module Three, students will explore 3-D modeling as a component of the field of Modeling and Simulation. Students will utilize SolidWorks modeling software to generate 3-D renderings of common classroom objects. A didactic video tutorial is provided to guide students through the process of rendering a filing cabinet. Following this experience, students will model a classroom object of their choosing; applying the SolidWorks techniques they have learned. Students will apply measuring techniques such as the use of a caliper when generating their high fidelity 3-D models. Finally, students will articulate the need for varied fidelity modeling in application in different real-world scenarios.
Module 4	In Module Four, students will investigate programming as a component of the field of Modeling and Simulation. First, students will investigate Scratch, a programming software with pre-programmed tiles that can be pieced together to accomplish tasks in a virtual environment. Next, students will read and complete activities from a Python programming text, *Invent Your Own Computer Games with Python.* In these activities, students will learn the commands and syntax of programming specific to Python. Following this introduction, students will write a program that represents the Fibonacci sequence as a mathematical model. Students will develop this program in its entirety, and will then apply their understanding of source code to the analysis of their stride rate data from Module Two. Students will modify an existing Python program to allow it to read their CSV file and make conclusions about the evacuation scenario. Finally, students will generate a program that simulates the exponential growth of fire in the evacuation network. They will apply their understanding of exponential functions and Python programming to verify the program as a constructive simulation.

Module 5	In Module Five, students are formally introduced to the capstone project and the Valve software that will be utilized for its completion. Using tutorial resources, students will generate a sample virtual map with the various functions of the Half-Life 2's, Hammer Editor. Through guided practice with the software features, students will develop the skills necessary for completion of the course capstone project. Additionally students will reflect upon their conceptual understanding of Modeling and Simulation by making additions to their previously generated concept map. A midterm take home exam that reflects the course enduring understandings is also provided as a summative assessment.
Module 6	Module Six encompasses an entire school quarter (45 school days) of classroom time and is entirely devoted to the course capstone project. Students will develop a virtual environment that resembles the evacuation network blueprint identified in Module Two, and apply acquired course concepts to the creation of a school evacuation simulation. Students will incorporate their knowledge of 3-D modeling, computer programming, and serious game level development as they apply the Engineering Design Process to their capstone project. They will consider facets of Modeling and Simulation such as fidelity, validity, and verifiability at each stage of development, and will make informed decisions about their project. Upon completion of simulation development, students will compose a summative verification study that evaluates their capstone project.

Conceptual Threads

Modeling and Simulation Concept	Experiential Learning
Engineering Design Process	Students will continuously employ the tenets of the Engineering Design Process as they learn how to design models and simulations at varying levels of fidelity.
Live Simulation	Wooden Trebuchet (Module 1)
Virtual Simulation	*Any instance in which the user is controlling a Non-Player Character in real time.
Constructive Simulation	VirtualTrebuchet.com Non-Player Characters Network Path (Module 6) Fire Spread Formula: adding the function of time(Module 4) Fire (Module 6)
Physical Models	SolidWorks Filing Cabinet (Module 3) SolidWorks Classroom Object (Module 3) School/Hallway (Module 6)
Mathematical Models	m&m™ Excel Task (Module 1) Excel Stride Rate Task (Module 2) Fire Formula: $A=A_0 e^{kt}$ (Module 4)
Process Models	Speedy Delivery Network (Module 2) Evacuation Network Path (Module 2) Use Case Diagram (Module 6)
Fidelity	SolidWorks Filing Cabinet: High Fidelity (Module 3) SolidWorks Classroom Object: Student determined level of fidelity (Module 3) *Your First Map*: Low-medium level of fidelity (Module 5) Virtual Model of Evacuation Network: Low-medium level of fidelity (Module 6)
Software Validation	VirtualTrebuchet.com (Module 1) Virtual Model of Evacuation Network (Module 6) Non-player Character (NPC) Evacuation (Module 6)
Software Verification	Fire Spread Python Task (Module 4) Capstone Project (Module 6)

Education Management Information System Coding

(Possible considerations based on specific teacher and school)

Subject Code	Description	Suggested Subject Area of Credit	Core Subject Area (for HQT)
119999	**Other Mathematics Course** High school level elective course that addresses advanced mathematical topics. Course Other mathematics course for which high school credit can be earned that is different in scope from any of the other SUBJECT CODES described above.	MTH	Math
107450	**Foundations of Technology** Prepares students to understand and apply technological concepts and processes that are the cornerstone for the high school technology program. Group and individual activities engage students in creating ideas, developing innovations and engineering practical solutions. Technology content, resources and laboratory/classroom activities apply student applications of science, mathematics and other school subjects in authentic situations. This course will focus on the three dimensions of technological literacy: knowledge, ways of thinking and acting, and capabilities, with the goal of students developing the characteristics of technologically literate citizens.	TEC	---
101720	**Design** Course includes design topics from the 9-12 portion of Ohio's technology academic content standards; including identifying and producing a product or system using a design process and evaluating the final solution, and communicating findings; recognizing the role of teamwork in engineering design and of prototyping in the design process; and understanding and applying research, development, and experimentation to problem-solving.	TEC	---
171821	**Computational Science and Engineering** Combined with Engineering Science (subject code 171815), utilizes business and industry technical standards and math, science and technology framework to introduce concepts of the utilization of mathematical formulas to serve as forecasting models across multiple industries in a problem-based format.	CTA, TEC	---

Academic Content Standards

The following list of standards outlines possible standards application for the course. This should be used as a guide with the understanding that each school will likely align the course to its own needs and specifications. Science standards were taken from the Next Generation Science Standards due to the inclusion of engineering design principles and specific reference to the Modeling and Simulation discipline. The Engineering and Science standards were taken from Ohio's Career Field Technical Content Standards. English Language Arts and Mathematics standards were taken from the Common Core State Standards to reflect current and relevant application to curriculum.

Next Generation Science Standards

HS: Engineering Design	
Performance Expectations	Students who demonstrate understanding can: **HS-ETS1-1.** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. **HS-ETS1-2**. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **HS-ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. **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.
Science and Engineering Practices	**Asking Questions and Defining Problems** Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1) **Using Mathematics and Computational Thinking** Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8

	experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories. • Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2) • Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)
Disciplinary Core Ideas	**ETS1.A: Defining and Delimiting Engineering Problems** • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1) • Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1) **ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4) **ETS1.C: Optimizing the Design Solution** • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2)
Crosscutting Concepts	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. (HS-ETS1-4)

Engineering and Science

Unit	Competencies
Unit 1: Career Exploration and Development	1.1 Explore careers in engineering and science. 1.3 Demonstrate positive work behaviors and personal qualities. 1.5 Employ critical thinking and problem solving skills independently or in teams to formulate solutions to problems. 1.6 Demonstrate the ability to lead or work on a team through team participation.
Unit 3: Communications	3.1 Write and utilize coherent, persuasive and focused technical communications that support a defined perspective for engineering and science. 3.2 Deliver formal and informal presentations that demonstrate organization and delivery skill. 3.3 Listen and speak effectively to contribute to group discussions and meetings. 3.4 Apply active listening skills to obtain and clarify information provided in oral communications. 3.5 Utilize written documents to direct engineering and science operations. 3.6 Explain and apply the fundamentals of engineering and science drawings, schematics, specifications and diagrams.
Unit 10: Introduction	10.2 Explore career pathways in engineering and engineering technology related to design.
Unit 11: Introduction to Design	11.1 Apply the steps of the design process to solve a variety of design problems. 11.2 Describe the application of the principles and elements of design utilized in products, print media and art forms.
Unit 13: Sketching and Visualization	13.1 Utilize sketching and visualization techniques. 13.2 Select and produce the appropriate pictorial style to best communicate solutions in the design process. 13.3 Evaluate and select the necessary view to graphically communicate design solutions.
Unit 14: Geometric Relationships	14.1 Construct various geometric forms and shapes.
Unit 15: Modeling	15.1 Communicate conceptual ideas through written and verbal formats. 15.2 Analyze and develop graphical representation of given data. 15.5 Evaluate a sketch and generate a model utilizing Computer Aided Design (CAD) software.
Unit 18: Model Documentation	18.1 Translate a three-dimensional drawing or model into corresponding orthographic drawing views. 18.2 Demonstrate appropriate dimensioning rules and practices. 18.3 Apply appropriate annotations on sketches and drawings.
Unit 19: Presentation	19.1 Practice effective oral communication techniques. 19.2 Utilize the most appropriate presentation aids in oral and written presentations.
Unit 20: Production	20.3 Discuss trends in automated manufacturing.

Unit 22: Definition and Types of Engineering and Engineering Technology	22.2 Interpret the role of an engineering and engineering technology team. 22.3 Explore careers in engineering and engineering technology.
Unit 23: Communication and Documentation	23.1 Compose sketches using proper sketching techniques in the solution of design problems. 23.2 Research a career field in engineering and engineering technology; document this research in a written technical report. 23.3 Prepare and deliver a technical presentation.
Unit 24: Design Process	24.2 Design a product.
Unit 40: Computer Modeling	40.1 Demonstrate the fundamentals of computer modeling. 40.2 Utilize object construction techniques. 40.3 Illustrate parts modeling techniques. 40.4 Develop multi-view drawings such as top, front, right side, isometric, section and auxiliary views from the solid model. 40.5 Create assembly models through the integration of individual parts and sub-assemblies 40.6 Prepare a rapid prototype file from a drawing database.
Unit 41: Programmable Machines	41.5 Make precision measurements to the degree of accuracy required by plan specification, using appropriate instruments.
Unit 81: Introduction to Engineering Design and Development	81.1 Identify the scope of and purpose for an engineering design and development research project.
Unit 82: Elements of Formal Research	82.1 Use a journal as the source for returning to any desired previously encountered information. 82.3 Use the computer as a research tool.
Unit 83: Guided Research	83.1 Demonstrate methods of brainstorming. 83.2 Research a topic. 83.3 Formulate a hypothesis and a problem statement. 83.4 Research and develop alternative solutions. 83.5 Redefine and justify alternative solutions. 83.6 Demonstrate presentation methods.
Unit 84: Independent Research	84.2 Develop a prototype. 84.3 Prepare a research paper.
Unit 86: Technical Drawing	86.1 Demonstrate technical applications common to all types of drafting. 86.2 Construct various geometric forms and shapes. 86.3 Produce basic orthographic drawings. 86.4 Sketch views of given objects. 86.6 Demonstrate computer-aided drafting and design (CADD) skills. 86.7 Evaluate a sketch and generate a model utilizing CAD software. 86.11 Demonstrate technical skills for making a reverse engineered drawing from a solid object.
Unit 97: Engineering Technology Capstone Project	97.1 Develop a team-based, real-world model project. 97.2 Present an oral report regarding the design and development of a project.

Mathematics

Conceptual Category	Algebra
Domain	Creating Equations
Cluster	Create equations that describe numbers or relationships
Standards	2. Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. 4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R.

Conceptual Category	Functions
Domain	Interpreting Functions
Cluster	Understand the concept of a function and use function notation
Standards	2. Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context. 3. Recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers. For example, the Fibonacci sequence is defined recursively by F(0) = F(1) = 1, f(n + 1) = f(n) + f (n – 1) for n ≥ 1.

Conceptual Category	Functions
Domain	Interpreting Functions
Cluster	Interpret functions that arise in applications in terms of the context
Standards	5. Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. For example, if the function h(n) gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain for the function. 6. Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph.

Conceptual Category	Functions
Domain	Interpreting Functions
Cluster	Analyze functions using different representations
Standards	8. Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. b. Use the properties of exponents to interpret expressions for exponential functions. For example, identify percent rate of change in functions such as y = (1.02)5, y = (0.97)5, y = (1.01)12t, y = (1.2)t/10, and classify them as representing exponential growth or decay.

Conceptual Category	**Functions**
Domain	Building Functions
Cluster	Build a function that models a relationship between two quantities
Standards	1. Write a function that describes a relationship between two quantities. (a) Determine an explicit expression, a recursive process, or steps for calculation from a context. (b) Combine standard function types using arithmetic operations. For example, build a function that models the temperature of a cooling body by adding a constant function to a decaying exponential and relate these functions to the model. (c) (+) Compose functions. For example, if T(y) is the temperature in the atmosphere as a function of height, and h(t) is the height of a weather balloon as a function of time, then T(h(t)) is the temperature at the location of the weather balloon as a function of time. 2. Write arithmetic and geometric sequences both recursively and with an explicit formula; use them to model situations, and translate between the two forms.

Conceptual Category	**Functions**
Domain	Linear and Exponential Models
Cluster	Construct and compare linear and exponential models and solve problems
Standards	1. Distinguish between situations that can be modeled with linear functions and with exponential functions. a. Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals. b. Recognize situations in which one quantity changes at a constant rate per unit interval relative to another. c. Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another. 2. Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table.) 4. For exponential models, express as a logarithm the solution to abct = d where a, c, and d are numbers and the base b is 2, 10, or e; evaluate the logarithm using technology.

Conceptual Category	**Functions**
Domain	Linear and Exponential Models
Cluster	Interpret expressions for functions in terms of the situation they model
Standards	5. Interpret the parameters in a linear or exponential function in terms of a context.

Conceptual Category	**Statistics and Probability**
Domain	Interpreting Categorical and Quantitative Data

Cluster	Summarize, represent, and interpret data on a single count or measurement variable
Standards	1. Represent data with plots on the real number line (dot plots, histograms, and box plots). 2. Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets. 3. Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).

Conceptual Category	**Statistics and Probability**
Domain	Interpreting Categorical and Quantitative Data
Cluster	Summarize, represent, and interpret data on two categorical and quantitative variables
Standards	6. Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. a. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context. Emphasize linear and exponential models. b. Informally assess the fit of a function by plotting and analyzing residents. c. Fit a linear function for a scatter plot that suggests a linear association.

Conceptual Category	**Statistics and Probability**
Domain	Interpreting Categorical and Quantitative Data
Cluster	Interpret Linear Models
Standards	7. Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data. 8. Compute (using technology) and interpret the correlation coefficient of a linear fit.

Conceptual Category	**Number and Quantity**
Domain	Quantities
Cluster	Reason quantitatively and use units to solve problems
Standards	1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. 2. Define appropriate quantities for the purpose of descriptive modeling. 3. Choose a level of accuracy appropriate to limitations on measurement reporting quantities

Conceptual Category	**Geometry**
Domain	Geometric Measurement and Dimension
Cluster	Visualize relationships between two-dimensional and three-dimensional objects

Standards	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.

Conceptual Category	**Geometry**
Domain	Modeling with Geometry
Cluster	Apply geometric concepts in modeling situations
Standards	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). 3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

English Language Arts

Grade	9-10
Strand	Writing
Topic	Text Types and Purposes
Standard	1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence. a. Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among claim(s), counterclaims, reasons, and evidence. b. Develop claim(s) and counterclaims fairly, supplying evidence for each while pointing out the strengths and limitations of both in a manner that anticipates the audience's knowledge level and concerns. c. Use words, phrases, and clauses to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims. d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. e. Provide a concluding statement or section that follows from and supports the argument presented. 2. Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content. a. Introduce a topic; organize complex ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. b. Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. c. Use appropriate and varied transitions to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts. d. Use precise language and domain-specific vocabulary to manage the complexity of the topic. e. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. f. Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).

Grade	11-12
Strand	Writing
Topic	Text Types and Purposes
Standard	1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence. a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences claim(s), counterclaims, reasons, and evidence. b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant evidence for each while pointing out the strengths and limitations of both in a manner that anticipates the audience's knowledge level, concerns, values, and possible biases. c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims. d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. e. Provide a concluding statement or section that follows from and supports the argument presented. 2. Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content. a. Introduce a topic; organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. c. Use appropriate and varied transitions and syntax to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts. d. Use precise language, domain-specific vocabulary, and techniques such as metaphor, simile, and analogy to manage the complexity of the topic. e. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. f. Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).