Spokane Public Schools
Principles of Engineering Design

Course: PLTW Principles of Engineering Design		**Total Framework Hours: 180**
CIP Code: 149992	☒**Exploratory** ☐**Preparatory**	**Date Last Modified: January 2015**
Career Cluster: Science, Technology, Engineering and Mathematics		**Cluster Pathway: Science & Math**

COMPONENTS AND ASSESSMENTS

Performance Assessments:

- Students will gain an understanding of mechanisms through the application of theory-based calculations accompanied by lab experimentation.
- Students will build simple and compound machines, calculate mechanical advantage and overall system efficiency.
- Students will investigate thermo energy and alternative energy applications in a lab experiment, and prove their understanding on a written examination.
- Students will build a solar and hydrogen fuel cell powered race car to compete in a 5 meter race. They will need to calculate the power output and overall efficiency of their race cars.

Leadership Alignment:

Classroom Focus:
Energy and Power - Build solar and hydrogen fuel cell powered car
Energy and Power - Mechanical Advantage
Energy and Power - Simple and Complex Machines

Community Focus:
JFRCR (Journal of FRC Engineering Research)

Example: Robotics – Students work as a team with engineering and mechanical mentors to brainstorm possible solutions to design and develop a robot to perform specific tasks. Solutions must be wildly creative in order to compete in regional events. Students will work through many design iterations, analyzing, evaluating and refining their ideas until a final prototype is built.

Example: Robotics – Students work in a team environment with fellow students, instructors, mentors, sponsors and robotic administrators. Students effectively communicate with all people involved, provide input and feedback, encourage one another, demonstrate inventiveness, fail often to succeed sooner, follow the Engineering Design Process, in order to contribute to the team and industry.

Example: Robotics – Students use their prior knowledge and observations to infer if ideas are possible or if they will work to the desired outcome. These ideas are effectively communicated to the team.

Example: Robotics – Students consider, design, test, analyze and evaluate how a robot's sub-systems interact with each other to produce the overall effectiveness of the robot.

Example: Robotics – Students work effectively with parties to brainstorm, design, build and operate a successful robot. They demonstrate flexibility to compromise and hold themselves and others accountable to accomplish the required goals.

Think Creatively: Use a wide range of idea creation techniques (such as brainstorming)
Think Creatively: Create new and worthwhile ideas (both incremental and radical concepts)
Think Creatively: Elaborate, refine, analyze and evaluate their own ideas in order to improve and maximize creative efforts
Work Creatively with Others: Develop, implement and communicate new ideas to others effectively.
Work Creatively with Others: Be open and responsive to new and diverse perspectives; incorporate group input and feedback into the work.
Work Creatively with Others: Demonstrate originality and inventiveness in work and understand the real world limits to adopting new ideas.
Work Creatively with Others: View failure as an opportunity to learn; understand that creativity and innovation is a long-term, cyclical process of small successes and frequent mistakes.
Implement Innovations: Act on creative ideas to make a tangible and useful contribution to the field in which the innovation will occur.
Reason Effectively: Use various types of reasoning (inductive, deductive, etc.) as appropriate to the situation.
Use Systems Thinking: Analyze how parts of a whole interact with each other to produce overall outcomes in complex systems
Collaborate with Others: Demonstrate ability to work effectively and respectfully with diverse teams.
Collaborate with Others: Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal.
Collaborate with Others: Assume shared responsibility for collaborative work, and value the individual contributions made by each team member.
Apply Technology Effectively: Use digital technologies (computers, PDAs, media players, GPS, etc.), communication/networking tools and social networks appropriately to access, manage, integrate, evaluate and create information to successfully function in a knowledge economy.
Manage Goals and Time: Utilize time and manage workload efficiently.
Work Independently: Monitor, define, prioritize and complete tasks without direct oversight.
Be Self-directed Learners: Go beyond basic mastery of skills and/or curriculum to explore and expand one‘s own learning and opportunities to gain expertise.
Manage Projects: Set and meet goals, even in the face of obstacles and competing pressures.
Manage Projects: Prioritize, plan and manage work to achieve the intended result.

Standards and Competencies

Standard/Unit: Energy & Power

Competencies	**Total Learning Hours for Unit: 49**

Students will demonstrate mastery of:

- simple machines and complex machines
- energy and power conversion
- mechanical advantage and overall system efficiency

Students will analyze and compare solar, and hydrogen power systems.
Students will experiment with and demonstrate understanding of thermo energy transfer through different materials.

Aligned Washington State Standards

Communications	**Comprehension and Collaboration 11-12** 1. Initiate and participate effectively in a range of collaborative discussions (one-on- one, in groups, and teacher-led) with diverse partners on *grades 11–12 topics, texts, and issues,* building on others’ ideas and expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to promote civil, democratic discussions and decision making, set clear goals and deadlines, and establish individual roles as needed. c. Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives. d. Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task.

	2. Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data. 3. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used. **Presentation of Knowledge and Ideas 11-12** 4. Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks. 5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. 6. Adapt speech to a variety of contexts and tasks, demonstrating a command of formal English when indicated or appropriate. Grades 11–12 Language standards 1 and 3 on page 54 for specific expectations.)
Educational Technology	1.1.1Generate ideas and create original works for personal and group expression using a variety of digital tools. 1.1.2 Use models and simulations to explore systems, identify trends and forecast possibilities. 1.2.1 Communicate and collaborate to learn with others. 1.3.1 Identify and define authentic problems and significant questions for investigation and plan strategies to guide inquiry. 1.3.2 Locate and organize information from a variety of sources and media. 1.3.3 Analyze, synthesize and ethically use information to develop a solution, make informed decisions and report results. 1.3.4 Use multiple processes and diverse perspectives to explore alternative solutions. 2.1.1 Practice personal safety. 2.1.2 Practice ethical and respectful behavior. 2.2.1 Develop skills to use technology effectively. 2.2.2 Use a variety of hardware to support learning. 2.3.1 Select and use common applications. 2.3.2 Select and use online applications. 2.4.1 Formulate and synthesize new knowledge.
Math	**The Real Number System N-RN** • Extend the properties of exponents to rational exponents 2. Rewrite expressions involving radicals and rational exponents using the properties of exponents. **Quantities N-Q** • Reason quantitatively and use units to solve problems 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 when reporting quantities. **Seeing Structure in Expressions A-SSE** • Interpret the structure of expressions 1. Interpret expressions that represent a quantity in terms of its context. a. Interpret parts of an expression, such as terms, factors, and coefficients. • Write expressions in equivalent forms to solve problems 3. Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. **Creating Equations A-CED** • Create equations that describe numbers or relationships 1. Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions.*

	2. Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. 3. Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. *For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.* 4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving **Reasoning with Equations and Inequalities A-REI** • Understand solving equations as a process of reasoning and explain the reasoning 1. Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method. 2. Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise. • Solve equations and inequalities in one variable 3. Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. Functions **Linear, Quadratic, and Exponential Models F-LE** • Construct and compare linear, quadratic, and exponential models and solve problems 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. • Interpret expressions for functions in terms of the situation they model 5. Interpret the parameters in a linear or exponential function in terms of a context.
Reading	**Reading For Literacy in Science and Technical Subjects 11-12** Key Ideas and Details 1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. 3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. Craft and Structure 4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 11–12 texts and topics*. 5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas. Integration of Knowledge and ideas 7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. 8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. 9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
Science	SYSA: Feedback is a process in which the output of a system provides information used to regulate the operation of the system. Positive feedback increases the disturbance to a system. Negative feedback reduces the disturbance to a system. SYSB: Systems thinking can be especially useful in analyzing complex situations. To be useful, a system needs to be specified as clearly as possible. INQA: Scientists generate and evaluate questions to investigate the natural world.

	INQB: Scientific progress requires the use of various methods appropriate for answering different kinds of research questions, a thoughtful plan for gathering data needed to answer the question, and care in collecting, analyzing, and displaying the data. INQC: Conclusions must be logical, based on evidence, and consistent with prior established knowledge. INQD: The methods and procedures that scientists use to obtain evidence must be clearly reported to enhance opportunities for further investigation. INQE: The essence of scientific investigation involves the development of a theory or conceptual model that can generate testable predictions. INQH: Scientists carefully evaluate sources of information for reliability before using that information. When referring to the ideas or findings of others, they cite their sources of information. APPB: The technological design process begins by defining a problem in terms of criteria and constraints, conducting research, and generating several different solutions. APPC: Choosing the best solution involves comparing alternatives with respect to criteria and constraints, then building and testing a model or other representation of the final design. APPD: The ability to solve problems is greatly enhanced by use of mathematics and information technologies. APPE: Perfect solutions do not exist. All technological solutions involve trade-offs in which decisions to include more of one quality means less of another. All solutions involve consequences, some intended, others not. APPF: It is important for all citizens to apply science and technology to critical issues that influence society. PS1G: Electrical force is a force of nature independent of gravity that exists between charged objects. Opposite charges attract while like charges repel. PS1H: Electricity and magnetism are two aspects of a single electromagnetic force. Moving electric charges produce magnetic forces, and moving magnets produce electric forces. PS2A: Atoms are composed of protons, neutrons, and electrons. The nucleus of an atom takes up very little of the atom's volume but makes up almost all of the mass. The nucleus contains protons and neutrons, which are much more massive than the electrons surrounding the nucleus. Protons have a positive charge, electrons are negative in charge, and neutrons have no net charge. PS2B: Atoms of the same element have the same number of protons. The number and arrangement of electrons determines how the atom interacts with other atoms to form molecules and ionic crystals. PS2C: When elements are listed in order according to the number of protons, repeating patterns of physical and chemical properties identify families of elements with similar properties. This Periodic Table is a consequence of the repeating pattern of outermost electrons. PS2D: Ions are produced when atoms or molecules lose or gain electrons, thereby gaining a positive or negative electrical charge. Ions of opposite charge are attracted to each other, forming ionic bonds. Chemical formulas for ionic compounds represent the proportion of ion of each element in the ionic crystal.
Writing	**Literacy in History/Social Studies, Science, and Technical Subjects 11/-12** Text Types and Purposes 1. Write arguments focused on *discipline-specific content.* 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 the claim(s), counterclaims, reasons, and evidence. 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 or supports the argument presented. **Production and Distribution of Writing 11-12** 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. 5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. 6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing

	feedback, including new arguments or information. Research to Build and Present Knowledge 7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. 8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. 9. Draw evidence from informational texts to support analysis, reflection, and research. **Language Standards** **Conventions of Standard English 9-10** 1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. a. Use parallel structure.* b. Use various types of phrases (noun, verb, adjectival, adverbial, participial, prepositional, absolute) and clauses (independent, dependent; noun, relative, adverbial) to convey specific meanings and add variety and interest to writing or presentations. 2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. a. Use a semicolon (and perhaps a conjunctive adverb) to link two or more closely related independent clauses. c. Spell correctly. **Knowledge of Language 9-10** 3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening. a. Write and edit work so that it conforms to the guidelines in a style manual (e.g., *MLA Handbook*, Turabian's *Manual for Writers*) appropriate for the discipline and writing type. **Vocabulary Acquisition and Use 9-10** 4. Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on *grades 9–10 reading and content*, choosing flexibly from a range of strategies. a. Use context (e.g., the overall meaning of a sentence, paragraph, or text; a word's position or function in a sentence) as a clue to the meaning of a word or phrase. b. Identify and correctly use patterns of word changes that indicate different meanings or parts of speech (e.g., *analyze, analysis, analytical; advocate, advocacy*). c. Consult general and specialized reference materials (e.g., dictionaries, glossaries, thesauruses), both print and digital, to find the pronunciation of a word or determine or clarify its precise meaning, its part of speech, or its etymology.

COMPONENTS AND ASSESSMENTS

Performance Assessments:

- Students will calculate internal and external forces of a truss. They will use this knowledge to design, build, and test their own truss bridge designs.
- Students will calculate the stress and strain different materials can withstand via a written exam.
- Students will compare their theoretical understanding of stress and strain to the real world using a Material Stress Analyzer.

Leadership Alignment:

Classroom Focus:
Materials and Structures - Bridge Building
Materials and Structures - Calculate Forces

Community Focus:
JFRCR (Journal of FRC Engineering Research)

Example: Robotics – Students work as a team with engineering and mechanical mentors to brainstorm possible solutions to design and develop a robot to perform specific tasks. Solutions must be wildly creative in order to compete in regional events. Students will work through many design iterations, analyzing, evaluating and refining their ideas until a final prototype is built.

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Manage Projects: Set and meet goals, even in the face of obstacles and competing pressures.
Manage Projects: Prioritize, plan and manage work to achieve the intended result.

Standards and Competencies

Standard/Unit: Materials and Structures

Competencies	**Total Learning Hours for Unit: 48**

- Students will identify and calculate forces acting on a body when it is in static equilibrium.
- Students will investigate the basic categories and properties of materials.
- Students will demonstrate understanding of how to calculate stress and strain on different materials.
- Students will discover how products are made and how they are recycled once they are no longer useful.

Aligned Washington State Standards

Communications	**Speaking and Listening Standards** **Comprehension and Collaboration 11-12** 1. Initiate and participate effectively in a range of collaborative discussions (one-on- one, in groups, and teacher-led) with diverse partners on *grades 11–12 topics, texts, and issues,* building on others' ideas and expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to promote civil, democratic discussions and decision making, set clear goals and deadlines, and establish individual roles as needed. c. Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives. d. Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the

	task. 2. Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data. 3. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used. **Presentation of Knowledge and Ideas 11-12** 4. Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks. 5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. 6. Adapt speech to a variety of contexts and tasks, demonstrating a command of formal English when indicated or appropriate. Grades 11–12 Language standards 1 and 3 on page 54 for specific expectations.)
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Math	Number and Quantity **The Real Number System N-RN** • Extend the properties of exponents to rational exponents 2. Rewrite expressions involving radicals and rational exponents using the properties of exponents. **Quantities N-Q** • Reason quantitatively and use units to solve problems 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 when reporting quantities. **Vector and Matrix Quantities N-VM** • Represent and model with vector quantities. 1. (+) Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes (e.g., $\boldsymbol{v}$, $\lvert\boldsymbol{v}\rvert$, $\lVert\boldsymbol{v}\rVert$, v). 2. (+) Find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point. 3. (+) Solve problems involving velocity and other quantities that can be represented by vectors. • Perform operations on vectors. 4. (+) Add and subtract vectors.

	a. Add vectors end-to-end, component-wise, and by the parallelogram rule. Understand that the magnitude of a sum of two vectors is typically not the sum of the magnitudes. b. Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum. c. Understand vector subtraction ***v*** – ***w*** as ***v*** + (–***w***), where –***w*** is the additive inverse of ***w***, with the same magnitude as ***w*** and pointing in the opposite direction. Represent vector subtraction graphically by connecting the tips in the appropriate order, and perform vector subtraction component-wise. 5. (+) Multiply a vector by a scalar. a. Represent scalar multiplication graphically by scaling vectors and possibly reversing their direction; perform scalar multiplication component-wise, e.g., as *c*(*v*x, *v*y) = (*cv*x, *cv*y). b. Compute the magnitude of a scalar multiple ***cv*** using ||***cv***|| = |*c*|*v*. Compute the direction of ***cv*** knowing that when |*c*|*v* ≠ 0, the direction of ***cv*** is either along ***v*** (for *c* > 0) or against ***v*** (for *c* < 0). Algebra **Seeing Structure in Expressions A-SSE** • Interpret the structure of expressions 1. Interpret expressions that represent a quantity in terms of its context. a. Interpret parts of an expression, such as terms, factors, and coefficients. b. Interpret complicated expressions by viewing one or more of their parts as a single entity. *For example, interpret P*(1+*r*)n *as the product of P and a factor not depending on P.* 2. Use the structure of an expression to identify ways to rewrite it. *For example, see x*4 – *y*4 *as* (*x*2)2 – (*y*2)2, *thus recognizing it as a difference of squares that can be factored as* (*x*2 – *y*2)(*x*2 + *y*2). • Write expressions in equivalent forms to solve problems 3. Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. **Creating Equations A-CED** • Create equations that describe numbers or relationships 1. Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions.* 2. Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. 3. Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. *For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.* 4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving **Reasoning with Equations and Inequalities A-REI** • Understand solving equations as a process of reasoning and explain the reasoning 1. Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method. 2. Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise. • Solve equations and inequalities in one variable 3. Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. 4. Solve quadratic equations in one variable. b. Solve quadratic equations by inspection (e.g., for *x*2 = 49), taking square roots, completing the square, the quadratic formula and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and write them as *a* ± *bi* for real numbers *a* and *b*. • Solve systems of equations 11. Explain why the *x*-coordinates of the points where the graphs of the equations *y* = *f*(*x*) and *y* = *g*(*x*) intersect are the solutions of the equation *f*(*x*) = *g*(*x*); find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find

	successive approximations. Include cases where *f*(*x*) and/or *g*(*x*) are linear, polynomial, rational, absolute value, exponential, and logarithmic functions. Functions **Interpreting Functions F-IF** • Interpret functions that arise in applications in terms of the context 4. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.* 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 • Analyze functions using different representations 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)t, y = (0.97)t, y = (1.01)12t, y = (1.2)t/10, and classify them as representing exponential growth or decay.* 9. Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). *For example, given a graph of one quadratic function and an algebraic expression for another, say which has the larger maximum.* **Building Functions F-BF** • Build a function that models a relationship between two quantities 1. Write a function that describes a relationship between two quantities. 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.* **Trigonometric Functions F-TF** • Extend the domain of trigonometric functions using the unit circle 1. Understand radian measure of an angle as the length of the arc on the unit circle subtended by the angle. 3. (+) Use special triangles to determine geometrically the values of sine, cosine, tangent for □/3, □/4 and □/6 unit circle to express the values of sine, cosine, and tangent for □−*x*, □+*x*, and 2□−*x* in terms of their values for *x*, where *x* is any real number. 4. (+) Use the unit circle to explain symmetry (odd and even) and periodicity of trigonometric functions. • Model periodic phenomena with trigonometric functions 5. Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline. 6. (+) Understand that restricting a trigonometric function to a domain on which it is always increasing or always decreasing allows its inverse to be constructed. 7. (+) Use inverse functions to solve trigonometric equations that arise in modeling contexts; evaluate the solutions using technology, and interpret them in terms of the context. • Prove and apply trigonometric identities 8. Prove the Pythagorean identity sin2(θ) + cos2(θ) = 1 and use it to find sin(θ), cos(θ), or tan(θ) given sin(θ), cos(θ), or tan(θ) and the quadrant of the angle. 9. (+) Prove the addition and subtraction formulas for sine, cosine, and tangent and use them to solve problems. Modeling Modeling Process may include: Problem->Formulate->Compute->Interpret->Validate->Formulate->Repeat cycle ->Report Geometry **Congruence G-CO**

	• Experiment with transformations in the plane 1. Know precise definitions of angle, circle, perpendicular line, parallel line, and line segment, based on the undefined notions of point, line, distance along a line, and distance around a circular arc. 8. Explain how the criteria for triangle congruence (ASA, SAS, and SSS) follow from the definition of congruence in terms of rigid motions. • Prove geometric theorems 9. Prove theorems about lines and angles. *Theorems include: vertical angles are congruent; when a transversal crosses parallel lines, alternate interior angles are congruent and corresponding angles are congruent; points on a perpendicular bisector of a line segment are exactly those equidistant from the segment's endpoints.* **Similarity, Right Triangles, and Trigonometry S-SRT** • Understand similarity in terms of similarity transformations 4. Prove theorems about triangles. *Theorems include: a line parallel to one side of a triangle divides the other two proportionally, and conversely; the Pythagorean Theorem proved using triangle similarity.* 5. Use congruence and similarity criteria for triangles to solve problems and to prove relationships in geometric figures. • Define trigonometric ratios and solve problems involving right triangles 7. Explain and use the relationship between the sine and cosine of complementary angles. 8. Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems. • Apply trigonometry to general triangles 9. (+) Derive the formula $A = 1/2\ ab \sin(C)$ for the area of a triangle by drawing an auxiliary line from a vertex perpendicular to the opposite side. 10. (+) Prove the Laws of Sines and Cosines and use them to solve problems. 11. (+) Understand and apply the Law of Sines and the Law of Cosines to find unknown measurements in right and non-right triangles (e.g., surveying problems, resultant forces). Statistics & Probability
Reading	**Reading For Literacy in Science and Technical Subjects 11-12** Key Ideas and Details 1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. 3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. Craft and Structure 4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 11–12 texts and topics*. 5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas. Integration of Knowledge and ideas 7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. 8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. 9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
Science	SYSD Systems can be changing or in equilibrium. APPB: The technological design process begins by defining a problem in terms of criteria and constraints, conducting research, and generating several different solutions. APPC: Choosing the best solution involves comparing alternatives with respect to criteria and constraints, then building and testing a model or other representation of the final design.

	APPD: The ability to solve problems is greatly enhanced by use of mathematics and information technologies. APPE: Perfect solutions do not exist. All technological solutions involve trade-offs in which decisions to include more of one quality means less of another. All solutions involve consequences, some intended, others not. PS1E: Whenever one object exerts a force on another object, a force of equal magnitude is exerted on the first object in the opposite direction. (Newton's Third Law of Motion) PS1F: Gravitation is a universal attractive force by which objects with mass attract one another. The gravitational force between two objects is proportional to their masses and inversely proportional to the square of the distance between the objects. (Newton's Law of Universal Gravitation) PS3C: Gravitational potential energy is due to the separation of mutually attracting masses. Transformations can occur between gravitational potential energy and kinetic energy, but the total amount of energy remains constant.
Writing	**Literacy in History/Social Studies, Science, and Technical Subjects 11/-12** Text Types and Purposes 1. Write arguments focused on *discipline-specific content.* 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 the claim(s), counterclaims, reasons, and evidence. 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 or supports the argument presented. **Production and Distribution of Writing 11-12** 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. 5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. 6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information. Research to Build and Present Knowledge 7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. 8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. 9. Draw evidence from informational texts to support analysis, reflection, and research. **Language Standards** **Conventions of Standard English 9-10** 1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. b. Use various types of phrases (noun, verb, adjectival, adverbial, participial, prepositional, absolute) and clauses (independent, dependent; noun, relative, adverbial) to convey specific meanings and add variety and interest to writing or presentations. 2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. a. Use a semicolon (and perhaps a conjunctive adverb) to link two or more closely related independent clauses. c. Spell correctly. **Knowledge of Language 9-10** 3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening. a. Write and edit work so that it conforms to the guidelines in a style manual

	(e.g., *MLA Handbook*, Turabian's *Manual for Writers*) appropriate for the discipline and writing type. **Vocabulary Acquisition and Use 9-10** 4. Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on *grades 9–10 reading and content*, choosing flexibly from a range of strategies. a. Use context (e.g., the overall meaning of a sentence, paragraph, or text; a word's position or function in a sentence) as a clue to the meaning of a word or phrase. b. Identify and correctly use patterns of word changes that indicate different meanings or parts of speech (e.g., *analyze, analysis, analytical; advocate, advocacy*). c. Consult general and specialized reference materials (e.g., dictionaries, glossaries, thesauruses), both print and digital, to find the pronunciation of a word or determine or clarify its precise meaning, its part of speech, or its etymology.

COMPONENTS AND ASSESSMENTS

Performance Assessments:

Students will:

- Design, create, and test a hydraulic device
- Design, create, and test a pneumatic device

On a written examination and on a physical device, students will:

- Calculate values in a fluid power system utilizing Pascal's Law
- Calculate values in a pneumatic system utilizing the perfect gas laws
- Calculate flow rate, flow velocity, and mechanical advantage in a hydraulic system

Students will design a fully-programmable, automated system to separate recyclable materials.

Leadership Alignment:

Classroom Project:
Control Systems - Create and Utilize Flowcharts

Community Event:
Robotics – Students consider, design, test, analyze and evaluate how a robot's sub-systems interact with each other to produce the overall effectiveness of the robot.

Think Creatively: Use a wide range of idea creation techniques (such as brainstorming)
Think Creatively: Create new and worthwhile ideas (both incremental and radical concepts)
Think Creatively: Elaborate, refine, analyze and evaluate their own ideas in order to improve and maximize creative efforts
Work Creatively with Others: Develop, implement and communicate new ideas to others effectively.
Work Creatively with Others: Be open and responsive to new and diverse perspectives; incorporate group input and feedback into the work.
Work Creatively with Others: Demonstrate originality and inventiveness in work and understand the real world limits to adopting new ideas.
Work Creatively with Others: View failure as an opportunity to learn; understand that creativity and innovation is a long-term, cyclical process of small successes and frequent mistakes.
Implement Innovations: Act on creative ideas to make a tangible and useful contribution to the field in which the innovation will occur.
Reason Effectively: Use various types of reasoning (inductive, deductive, etc.) as appropriate to the situation.
Use Systems Thinking: Analyze how parts of a whole interact with each other to produce overall outcomes in complex systems
Collaborate with Others: Demonstrate ability to work effectively and respectfully with diverse teams.
Collaborate with Others: Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal.
Collaborate with Others: Assume shared responsibility for collaborative work, and value the individual contributions made by each team member.
Apply Technology Effectively: Use digital technologies (computers, PDAs, media players, GPS, etc.), communication/networking tools and social networks appropriately to access, manage, integrate, evaluate and create information to successfully function in a knowledge economy.
Manage Goals and Time: Utilize time and manage workload efficiently.
Work Independently: Monitor, define, prioritize and complete tasks without direct oversight.

Be Self-directed Learners: Go beyond basic mastery of skills and/or curriculum to explore and expand one's own learning and opportunities to gain expertise.
Manage Projects: Set and meet goals, even in the face of obstacles and competing pressures.
Manage Projects: Prioritize, plan and manage work to achieve the intended result.

Standards and Competencies

Standard/Unit: Control Systems

Competencies	**Total Learning Hours for Unit: 53**

In this unit, students will demonstrate their understanding of:

- How to create and interpret a flow chart
- How to create control system operating programs that utilize computer software
- How to create control system programs that utilize flow chart logic
- The difference between open loop and closed loop systems
- The differences between analog and digital devices
- How to design a control system based on given needs and constraints
- The differences between pneumatic and hydraulic systems.

Students will:

- Distinguish between pressure and absolute pressure.
- Distinguish between temperature and absolute temperature.

Aligned Washington State Standards

Communications	**Speaking and Listening Standards** **Comprehension and Collaboration 11-12** 1. Initiate and participate effectively in a range of collaborative discussions (one-on- one, in groups, and teacher-led) with diverse partners on *grades 11–12 topics, texts, and issues,* building on others' ideas and expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to promote civil, democratic discussions and decision making, set clear goals and deadlines, and establish individual roles as needed. c. Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives. d. Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task. 2. Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data. 3. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used. **Presentation of Knowledge and Ideas 11-12** 4. Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks. 5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. 6. Adapt speech to a variety of contexts and tasks, demonstrating a command of formal English when indicated or appropriate. Grades 11–12 Language standards 1 and 3 on page 54 for specific expectations.)

Educational Technology	1.1.1Generate ideas and create original works for personal and group expression using a variety of digital tools. 1.1.2 Use models and simulations to explore systems, identify trends and forecast possibilities. 1.2.1 Communicate and collaborate to learn with others. 1.3.1 Identify and define authentic problems and significant questions for investigation and plan strategies to guide inquiry. 1.3.2 Locate and organize information from a variety of sources and media. 1.3.3 Analyze, synth+9qqqesize and ethically use information to develop a solution, make informed decisions and report results. 1.3.4 Use multiple processes and diverse perspectives to explore alternative solutions. 2.1.1 Practice personal safety. 2.1.2 Practice ethical and respectful behavior. 2.2.1 Develop skills to use technology effectively. 2.2.2 Use a variety of hardware to support learning. 2.3.1 Select and use common applications. 2.3.2 Select and use online applications. 2.4.1 Formulate and synthesize new knowledge.
Math	Number and Quantity **The Real Number System N-RN** • Extend the properties of exponents to rational exponents **Quantities N-Q** • Reason quantitatively and use units to solve problems 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 when reporting quantities. **Seeing Structure in Expressions A-SSE** • Interpret the structure of expressions 1. Interpret expressions that represent a quantity in terms of its context. a. Interpret parts of an expression, such as terms, factors, and coefficients. b. Interpret complicated expressions by viewing one or more of their parts as a single entity. *For example, interpret P*(1+*r*)n *as the product of P and a factor not depending on P.* 2. Use the structure of an expression to identify ways to rewrite it. *For example, see x*4 – *y*4 *as* (*x*2)2 – (*y*2)2, *thus recognizing it as a difference of squares that can be factored as* (*x*2 – *y*2)(*x*2 + *y*2). • Write expressions in equivalent forms to solve problems 3. Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. **Creating Equations A-CED** • Create equations that describe numbers or relationships 1. Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions.* 2. Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. 3. Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. *For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.* 4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving Functions **Linear, Quadratic, and Exponential Models F-LE** • Construct and compare linear, quadratic, and exponential models and solve problems

	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). 5. Interpret the parameters in a linear or exponential function in terms of a context. Geometry
Reading	**Reading For Literacy in Science and Technical Subjects 11-12** Key Ideas and Details 1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. 3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. Craft and Structure 4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 11–12 texts and topics*. 5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas. Integration of Knowledge and ideas 7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. 8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. 9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
Science	SYSB: Systems thinking can be especially useful in analyzing complex situations. To be useful, a system needs to be specified as clearly as possible. SYSC: In complex systems, entirely new and unpredictable properties may emerge. Consequently, modeling a complex system in sufficient detail to make reliable predictions may not be possible. SYSD Systems can be changing or in equilibrium. INQA: Scientists generate and evaluate questions to investigate the natural world. INQB: Scientific progress requires the use of various methods appropriate for answering different kinds of research questions, a thoughtful plan for gathering data needed to answer the question, and care in collecting, analyzing, and displaying the data. INQC: Conclusions must be logical, based on evidence, and consistent with prior established knowledge. INQD: The methods and procedures that scientists use to obtain evidence must be clearly reported to enhance opportunities for further investigation. INQE: The essence of scientific investigation involves the development of a theory or conceptual model that can generate testable predictions. INQH: Scientists carefully evaluate sources of information for reliability before using that information. When referring to the ideas or findings of others, they cite their sources of information. APPB: The technological design process begins by defining a problem in terms of criteria and constraints, conducting research, and generating several different solutions. APPC: Choosing the best solution involves comparing alternatives with respect to criteria and constraints, then building and testing a model

	or other representation of the final design. APPD: The ability to solve problems is greatly enhanced by use of mathematics and information technologies. APPE: Perfect solutions do not exist. All technological solutions involve trade-offs in which decisions to include more of one quality means less of another. All solutions involve consequences, some intended, others not. PS1D: A net force will cause an object to accelerate or change direction. A less massive object will speed up more quickly than a more massive object subjected to the same force. (Newton's Second Law of Motion, F=ma) PS1E: Whenever one object exerts a force on another object, a force of equal magnitude is exerted on the first object in the opposite direction. (Newton's Third Law of Motion) PS1F: Gravitation is a universal attractive force by which objects with mass attract one another. The gravitational force between two objects is proportional to their masses and inversely proportional to the square of the distance between the objects. (Newton's Law of Universal Gravitation) PS3C: Gravitational potential energy is due to the separation of mutually attracting masses. Transformations can occur between gravitational potential energy and kinetic energy, but the total amount of energy remains constant.
Writing	**Literacy in History/Social Studies, Science, and Technical Subjects 11/-12** Text Types and Purposes 1. Write arguments focused on *discipline-specific content.* 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 the claim(s), counterclaims, reasons, and evidence. 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 or supports the argument presented. **Production and Distribution of Writing 11-12** 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. 5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. 6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information. Research to Build and Present Knowledge 7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. 8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. 9. Draw evidence from informational texts to support analysis, reflection, and research. **Language Standards** **Conventions of Standard English 9-10** 1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. b. Use various types of phrases (noun, verb, adjectival, adverbial, participial, prepositional, absolute) and clauses (independent, dependent; noun, relative, adverbial) to convey specific meanings and add variety and interest to writing or presentations. 2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. a. Use a semicolon (and perhaps a conjunctive adverb) to link two or more closely related independent clauses. c. Spell correctly. **Knowledge of Language 9-10**

	3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening. a. Write and edit work so that it conforms to the guidelines in a style manual (e.g., *MLA Handbook*, Turabian's *Manual for Writers*) appropriate for the discipline and writing type. **Vocabulary Acquisition and Use 9-10** 4. Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on *grades 9–10 reading and content*, choosing flexibly from a range of strategies. a. Use context (e.g., the overall meaning of a sentence, paragraph, or text; a word's position or function in a sentence) as a clue to the meaning of a word or phrase. b. Identify and correctly use patterns of word changes that indicate different meanings or parts of speech (e.g., *analyze, analysis, analytical; advocate, advocacy*). c. Consult general and specialized reference materials (e.g., dictionaries, glossaries, thesauruses), both print and digital, to find the pronunciation of a word or determine or clarify its precise meaning, its part of speech, or its etymology.

COMPONENTS AND ASSESSMENTS

Performance Assessments:
Students will gather, organize, and interpret experimental data both visually and orally to the class.
Students will use data to make predictions and informed decisions on a written examination.
Students will build a ballistics device and use their knowledge of kinematics to win a life-size game of Battleship.

Leadership Alignment:

Classroom Focus:
Statistics and Kinematics - Gather and interpret experimental data. Use data to make predictions and informed decisions
Statistics and Kinematics - Gather, organize, and interpret experimental data both visually and orally to the class
Statistics and Kinematics - Gather, organize, and interpret data. Use data to make predictions.

Community Focus:

JFRCR (Journal of FRC Engineering Research)

Example: Robotics – Students access information from the Internet using a variety of media in order to self-educate and evaluate the robotic and competition requirements. Students research and keep track of the best information sources in order to proceed effectively through the design and build stages. This information comes from a variety of sources (mentors, sponsors, competition, senior teams, industry and equipment manufacturers).

Example: Robotics – Students manage and document the updated information throughout the build stage in order to keep up on the continual changes to the requirements, hardware and software upgrades

Think Creatively: Use a wide range of idea creation techniques (such as brainstorming)
Think Creatively: Create new and worthwhile ideas (both incremental and radical concepts)
Think Creatively: Elaborate, refine, analyze and evaluate their own ideas in order to improve and maximize creative efforts
Work Creatively with Others: Develop, implement and communicate new ideas to others effectively.
Work Creatively with Others: Be open and responsive to new and diverse perspectives; incorporate group input and feedback into the work.
Work Creatively with Others: Demonstrate originality and inventiveness in work and understand the real world limits to adopting new ideas.
Work Creatively with Others: View failure as an opportunity to learn; understand that creativity and innovation is a long-term, cyclical process of small successes and frequent mistakes.
Implement Innovations: Act on creative ideas to make a tangible and useful contribution to the field in which the innovation will occur.
Reason Effectively: Use various types of reasoning (inductive, deductive, etc.) as appropriate to the situation.

Use Systems Thinking: Analyze how parts of a whole interact with each other to produce overall outcomes in complex systems
Collaborate with Others: Demonstrate ability to work effectively and respectfully with diverse teams.
Collaborate with Others: Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal.
Collaborate with Others: Assume shared responsibility for collaborative work, and value the individual contributions made by each team member.
Apply Technology Effectively: Use digital technologies (computers, PDAs, media players, GPS, etc.), communication/networking tools and social networks appropriately to access, manage, integrate, evaluate and create information to successfully function in a knowledge economy.
Manage Goals and Time: Utilize time and manage workload efficiently.
Work Independently: Monitor, define, prioritize and complete tasks without direct oversight.
Be Self-directed Learners: Go beyond basic mastery of skills and/or curriculum to explore and expand one's own learning and opportunities to gain expertise.
Manage Projects: Set and meet goals, even in the face of obstacles and competing pressures.
Manage Projects: Prioritize, plan and manage work to achieve the intended result.

Standards and Competencies

Standard/Unit: Statistics and Kinematics

Competencies	**Total Learning Hours for Unit: 30**

- Students will analyze, and demonstrate an understanding of gathering, organizing, and interpreting data in order to formulate hypotheses and informed decisions.
- Students will analyze and make use of how forces affect projectile motion.

Aligned Washington State Standards

Communications	**Speaking and Listening Standards** **Comprehension and Collaboration 11-12** 1. Initiate and participate effectively in a range of collaborative discussions (one-on- one, in groups, and teacher-led) with diverse partners on *grades 11–12 topics, texts, and issues,* building on others' ideas and expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to promote civil, democratic discussions and decision making, set clear goals and deadlines, and establish individual roles as needed. c. Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives. d. Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task. 2. Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data. 3. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used. **Presentation of Knowledge and Ideas 11-12** 4. Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks. 5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. 6. Adapt speech to a variety of contexts and tasks, demonstrating a command of formal English when indicated or appropriate. Grades 11–12 Language standards 1 and 3 on page 54 for specific expectations.)
Educational Technology	1.1.1Generate ideas and create original works for personal and group expression using a variety of digital tools. 1.1.2 Use models and simulations to explore systems, identify trends and forecast possibilities.

	1.2.1 Communicate and collaborate to learn with others. 1.3.1 Identify and define authentic problems and significant questions for investigation and plan strategies to guide inquiry. 1.3.2 Locate and organize information from a variety of sources and media. 1.3.3 Analyze, synth+9qqqesize and ethically use information to develop a solution, make informed decisions and report results. 1.3.4 Use multiple processes and diverse perspectives to explore alternative solutions. 2.1.1 Practice personal safety. 2.1.2 Practice ethical and respectful behavior. 2.2.1 Develop skills to use technology effectively. 2.2.2 Use a variety of hardware to support learning. 2.3.1 Select and use common applications. 2.3.2 Select and use online applications. 2.4.1 Formulate and synthesize new knowledge.
Math	**Quantities N-Q** • Reason quantitatively and use units to solve problems 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 when reporting quantities. **Vector and Matrix Quantities N-VM** • Represent and model with vector quantities. 1. (+) Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes (e.g., ***v***, |***v***|, ||***v***||, *v*). 2. (+) Find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point. 3. (+) Solve problems involving velocity and other quantities that can be represented by vectors. • Perform operations on vectors. 4. (+) Add and subtract vectors. a. Add vectors end-to-end, component-wise, and by the parallelogram rule. Understand that the magnitude of a sum of two vectors is typically not the sum of the magnitudes. b. Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum. c. Understand vector subtraction ***v*** – ***w*** as ***v*** + (–***w***), where –***w*** is the additive inverse of ***w***, with the same magnitude as ***w*** and pointing in the opposite direction. Represent vector subtraction graphically by connecting the tips in the appropriate order, and perform vector subtraction component-wise. 5. (+) Multiply a vector by a scalar. a. Represent scalar multiplication graphically by scaling vectors and possibly reversing their direction; perform scalar multiplication component-wise, e.g., as *c*(*v*x, *v*y) = (*cv*x, *cv*y). b. Compute the magnitude of a scalar multiple ***cv*** using ||***cv***|| = |*c*|*v*. Compute the direction of ***cv*** knowing that when |*c*|*v* ≠ 0, the direction of ***cv*** is either along ***v*** (for *c* > 0) or against ***v*** (for *c* < 0). Algebra **Creating Equations A-CED** • Create equations that describe numbers or relationships 1. Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions.* 2. Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. 3. Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. *For example, represent inequalities describing nutritional and cost constraints on combinations of*

	different foods. 4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving **Reasoning with Equations and Inequalities A-REI** • Understand solving equations as a process of reasoning and explain the reasoning 1. Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method. • Solve systems of equations 10. Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line). 11. Explain why the *x*-coordinates of the points where the graphs of the equations $y = f(x)$ and $y = g(x)$ intersect are the solutions of the equation $f(x) = g(x)$; find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where $f(x)$ and/or $g(x)$ are linear, polynomial, rational, absolute value, exponential, and logarithmic functions. Functions **Interpreting Functions F-IF** • Interpret functions that arise in applications in terms of the context 4. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.* 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 • Analyze functions using different representations 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)t, y = (0.97)t, y = (1.01)12t, y = (1.2)t/10, and classify them as representing exponential growth or decay.* 9. Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). *For example, given a graph of one quadratic function and an algebraic expression for another, say which has the larger maximum.* **Building Functions F-BF** • Build a function that models a relationship between two quantities 1. Write a function that describes a relationship between two quantities. 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.* **Linear, Quadratic, and Exponential Models F-LE** • Construct and compare linear, quadratic, and exponential models and solve problems 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).

	3. Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or (more generally) as a polynomial function. 4. For exponential models, express as a logarithm the solution to *ab*ct = *d* where *a*, *c*, and *d* are numbers and • Interpret expressions for functions in terms of the situation they model 5. Interpret the parameters in a linear or exponential function in terms of a context. **Interpreting Categorical and Quantitative Data S-ID** • Summarize, represent, and interpret data on a single count or measurement variable 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). 4. Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, • Summarize, represent, and interpret data on two categorical and quantitative variables 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, quadratic, and exponential models.* b. Informally assess the fit of a function by plotting and analyzing residuals. c. Fit a linear function for a scatter plot that suggests a linear association. • Interpret linear models 8. Compute (using technology) and interpret the correlation coefficient of a linear fit.
Reading	**Reading For Literacy in Science and Technical Subjects 11-12** Key Ideas and Details 1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. 3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. Craft and Structure 4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 11–12 texts and topics*. 5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas. Integration of Knowledge and ideas 7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. 8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. 9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
Science	SYSB: Systems thinking can be especially useful in analyzing complex situations. To be useful, a system needs to be specified as clearly as possible. SYSC: In complex systems, entirely new and unpredictable properties may emerge. Consequently, modeling a complex system in sufficient detail to make reliable predictions may not be possible. SYSD Systems can be changing or in equilibrium. INQA: Scientists generate and evaluate questions to investigate the natural world.

	INQB: Scientific progress requires the use of various methods appropriate for answering different kinds of research questions, a thoughtful plan for gathering data needed to answer the question, and care in collecting, analyzing, and displaying the data. INQC: Conclusions must be logical, based on evidence, and consistent with prior established knowledge. INQD: The methods and procedures that scientists use to obtain evidence must be clearly reported to enhance opportunities for further investigation. INQE: The essence of scientific investigation involves the development of a theory or conceptual model that can generate testable predictions. APPB: The technological design process begins by defining a problem in terms of criteria and constraints, conducting research, and generating several different solutions. APPC: Choosing the best solution involves comparing alternatives with respect to criteria and constraints, then building and testing a model or other representation of the final design. APPD: The ability to solve problems is greatly enhanced by use of mathematics and information technologies. APPE: Perfect solutions do not exist. All technological solutions involve trade-offs in which decisions to include more of one quality means less of another. All solutions involve consequences, some intended, others not. PS1A: Average velocity is defined as a change in position with respect to time. Velocity includes both speed and direction. PS1B: Average acceleration is defined as a change in velocity with respect to time. Acceleration indicates a change in speed and/or a change in direction. PS1C: An object at rest will remain at rest unless acted on by an unbalanced force. An object in motion at constant velocity will continue at the same velocity unless acted on by an unbalanced force. (Newton's First Law of Motion, the Law of Inertia) PS1D: A net force will cause an object to accelerate or change direction. A less massive object will speed up more quickly than a more massive object subjected to the same force. (Newton's Second Law of Motion, F=ma) PS1E: Whenever one object exerts a force on another object, a force of equal magnitude is exerted on the first object in the opposite direction. (Newton's Third Law of Motion) PS1F: Gravitation is a universal attractive force by which objects with mass attract one another. The gravitational force between two objects is proportional to their masses and inversely proportional to the square of the distance between the objects. (Newton's Law of Universal Gravitation) PS3B: Kinetic energy is the energy of motion. The kinetic energy of an object is defined by the equation: $E_k = ½ mv^2$ PS3C: Gravitational potential energy is due to the separation of mutually attracting masses. Transformations can occur between gravitational potential energy and kinetic energy, but the total amount of energy remains constant.
Writing	**Literacy in History/Social Studies, Science, and Technical Subjects 11/-12** Text Types and Purposes 1. Write arguments focused on *discipline-specific content.* 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 the claim(s), counterclaims, reasons, and evidence. 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 or supports the argument presented. **Production and Distribution of Writing 11-12** 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. 5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. 6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information. Research to Build and Present Knowledge

	7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. 8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. 9. Draw evidence from informational texts to support analysis, reflection, and research. **Language Standards** **Conventions of Standard English 9-10** 1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. b. Use various types of phrases (noun, verb, adjectival, adverbial, participial, prepositional, absolute) and clauses (independent, dependent; noun, relative, adverbial) to convey specific meanings and add variety and interest to writing or presentations. 2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. a. Use a semicolon (and perhaps a conjunctive adverb) to link two or more closely related independent clauses. c. Spell correctly. **Knowledge of Language 9-10** 3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening. a. Write and edit work so that it conforms to the guidelines in a style manual (e.g., *MLA Handbook*, Turabian's *Manual for Writers*) appropriate for the discipline and writing type. **Vocabulary Acquisition and Use 9-10** 4. Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on *grades 9–10 reading and content*, choosing flexibly from a range of strategies. a. Use context (e.g., the overall meaning of a sentence, paragraph, or text; a word's position or function in a sentence) as a clue to the meaning of a word or phrase. b. Identify and correctly use patterns of word changes that indicate different meanings or parts of speech (e.g., *analyze, analysis, analytical; advocate, advocacy*). c. Consult general and specialized reference materials (e.g., dictionaries, glossaries, thesauruses), both print and digital, to find the pronunciation of a word or determine or clarify its precise meaning, its part of speech, or its etymology.

21st Century Skills		
Check those that students will demonstrate in this course:		
LEARNING & INNOVATION **Creativity and Innovation** ☒Think Creatively ☒Work Creatively with Others ☒Implement Innovations **Critical Thinking and Problem Solving** ☒Reason Effectively ☒**U**se Systems Thinking ☐Make Judgments and Decisions ☐Solve Problems **Communication and Collaboration** ☐Communicate Clearly ☒Collaborate with Others	**INFORMATION, MEDIA & TECHNOLOGY SKILLS** **Information Literacy** ☐Access and /evaluate Information ☐Use and Manage Information **Media Literacy** ☒Analyze Media ☐Create Media Products **Information, Communications and Technology (ICT Literacy)** ☒Apply Technology Effectively	**LIFE & CAREER SKILLS** **Flexibility and Adaptability** ☐Adapt to Change ☐Be Flexible **Initiative and Self-Direction** ☒Manage Goals and Time ☒Work Independently ☒Be Self-Directed Learners **Social and Cross-Cultural** ☐Interact Effectively with Others ☐Work Effectively in Diverse Teams **Productivity and Accountability** ☒Manage Projects ☐Produce Results **Leadership and Responsibility** ☐Guide and Lead Others ☐Be Responsible to Others