CAREER FOCUS

Power Line Engineer

ACADEMIC FOCUS

Discover the basic parameters of power plants and perform calculations using Ohm's Law to deduce the presence of resistance in wires over distance, as electricity moves from a plant to the city.

In PowerLine 2, students will participate in directed inquiry discussion on how power is supplied from a power plant to cities. Students will be immersed in topics including power generation, voltage, amperage, power, voltage drop, watts, conversion of watts to megawatts, correct calculation of power using a formula, utilization of Ohm's Law, and use of power grid nomenclature. Significant math will be required to complete the PowerLine 2 activities. Students will be encouraged to discuss the activity in the Whyville forums.

Contents of this lesson plan

Grant funding from the Texas Workforce Commission and U.S. Department of Labor. Grant funding from Next Generation Learning Challenges.

POWERLINE 2 in Whyville

TEACHER PREPARATION

Review this prior to class!

Instructional Approach

This lesson plan uses directed inquiry to lead students to discover the questions they should ask about a topic, and the answers to those questions.

Teacher's Role

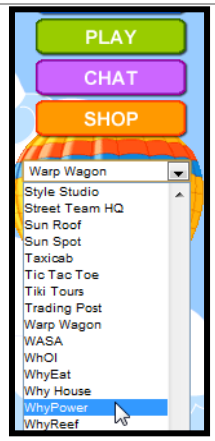
The teacher's role is classroom facilitator and expert consultant. You will lead students to explore and help them when they have problems. Many students will learn much more than is formally included in this lesson plan, and will also be able to help other students.

Materials

1. Computers with Internet access and confirmed access to Whyville
2. CONNECT worksheet, included in this lesson plan
3. Calculator (optional)

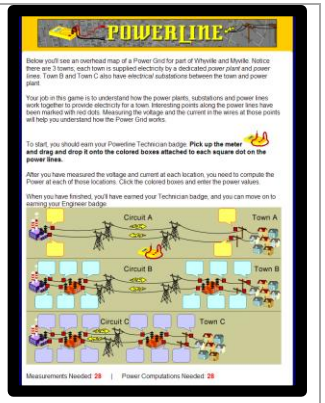
Follow these instructions to prepare to facilitate for your class.

1. Log into Whyville and select *WhyPower* from the pull-down menu→

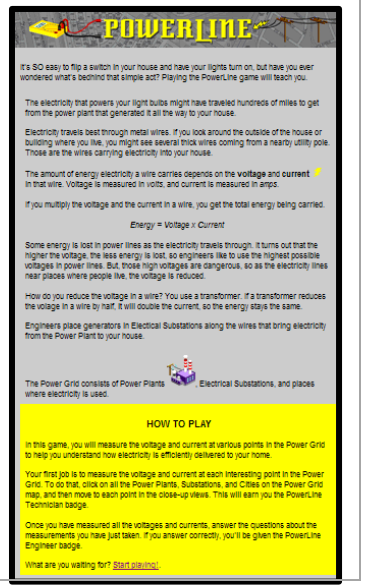


2. Click the link *WhyPower Station.*

3. Click the link *PowerLine ,* and then click the link for *Instructions*. You will arrive at the screens shown below.



4. Click on the "Start Playing!" link after reading all the instructions.



5. Students begin answering questions using the map and data they calculated in PowerLine 1. Questions will point out recognizable patterns, leading students to perform computations and fill in data tables, introducing them to Ohm's Law, and leading them to deductively reason the presence of resistance in power lines over distance and the resulting loss of energy to cities.

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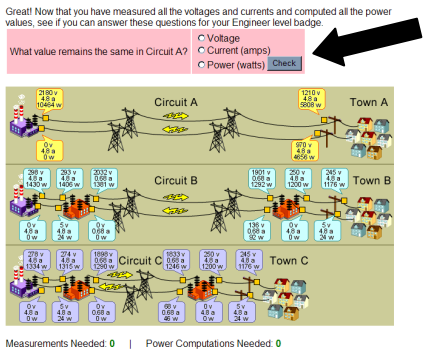
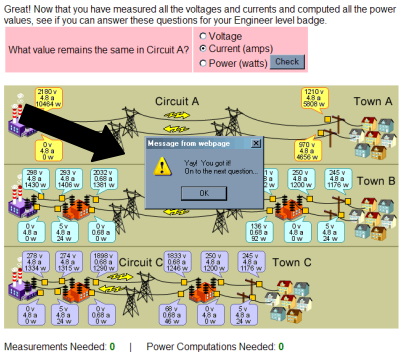
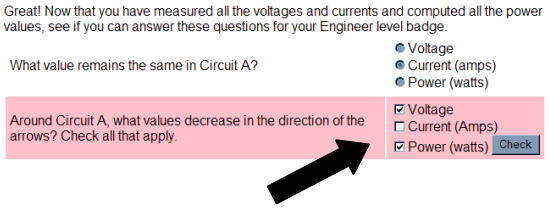


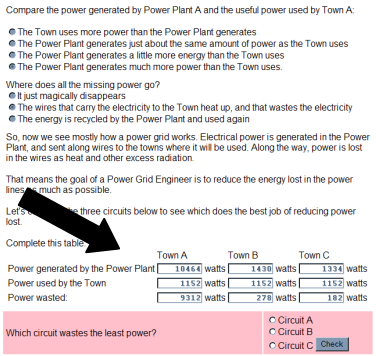
Students enter answers in different formats: multiple choice, true/false, fill-in-the-blank. They make computations for data tables.



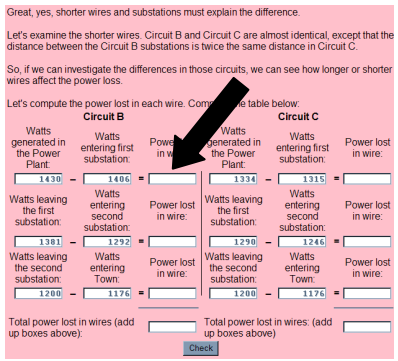
As they answer questions, a feedback dialog box leads them to the next question.



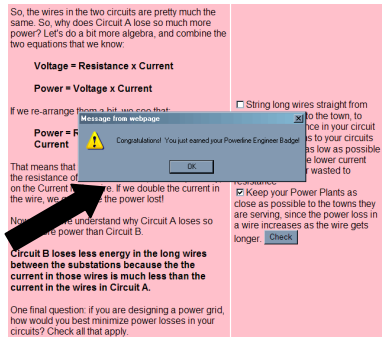
Each question leads the student to the next, in order to uncover new knowledge. The example above is a multiple choice question.



Data table example



Another example of the data tables



Finish all calculations

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6. Once the student answers all the questions, they will be given their PowerLine Engineer's badge.

Answer Key

1. Current (amps) 2. Voltage and Power (watts) 3. 240 volts 4. 1152 watts 5. The Power Plant generates much more power that the Town uses 6. The wires that carry electricity to the Town heat up, and that wastes the electricity 7. 9312 watts, 278 watts, 182 watts 8. Circuit C 9. Town C is closer to the power plant so the wires are shorter, The wires between the power plant and Town C go through two electrical substations.	10. Circuit B = 24+89+24=137; Circuit C = 19+44+24=87 11. All four boxes should be checked 12. The voltage leaving the substation is about 7 times the voltage entering. 13. The current leaving the substation is about 7 times less than the voltage entering 14. The power mostly stays the same in the substation, maybe dropping just a bit 15. Voltage Lost = 970, 5, 131, 5 and Resistance = 202, 1, 192, 1 16. Both circuits have about the same resistance. 17. Add substations to your circuits to get the current as low as possible in your wires, since lower current means less power wasted to resistance. Keep your Power Plants as close as possible to the towns they are serving, since the power loss in a wire increases as the wire gets longer.

7. The dialog then leads them to discuss the following question in the Whyville Forum:

> Do your results help explain why power is transferred for long distances via huge towers instead of regular telephone poles? Discuss this in the Forums

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SCIENCE

In the last lessons we exposed the students to kilowatts, kilowatt-hours and megawatts and megawatt-hours. In this lesson, students are introduced to measurements in **volts** and **amps** in order to calculate **power** in watts, which is *Power = Volts X Amps*. In addition, the key new concept is the idea of power being lost due to the resistance in supplying energy over long distances.

Also, students must calculate the voltage drop in transmission lines and utilize Ohm's Law to perform computations. A scientist named Jeorg Ohm figured out the relationship between Voltage, Current, and Resistance, so there's a rule called *Ohm's Law* that says: *Voltage = Resistance x Current*. A little algebra rewrites that as: *Resistance = Voltage ÷ Current.*

Ohm's principal discovery was that the amount of electric current through a metal conductor in a circuit is directly proportional to the voltage impressed across it. During the course of the students' calculations, the proportional relationship between voltage, amperage, and resistance should become evident.

We measure Resistance in Ohms, in honor of Jeorg Ohm.

MATH

There is much basic arithmetic in this lesson as voltage drop and watts are added, subtracted, multiplied, or divided to determine if the energy supply of a power plant is sufficient to supply a city over different distances with or without substations. Ohm's law uses proportions, which students will experience in real-world context. When students use a version of Ohm's law rewritten, for example, to isolate resistance, the dividend-divisor format introduces an inverse proportion.

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CAREERS

Boiler Operator
Description: Operates automatically fired boilers to generate steam that supplies heat or power for buildings or industrial processes.

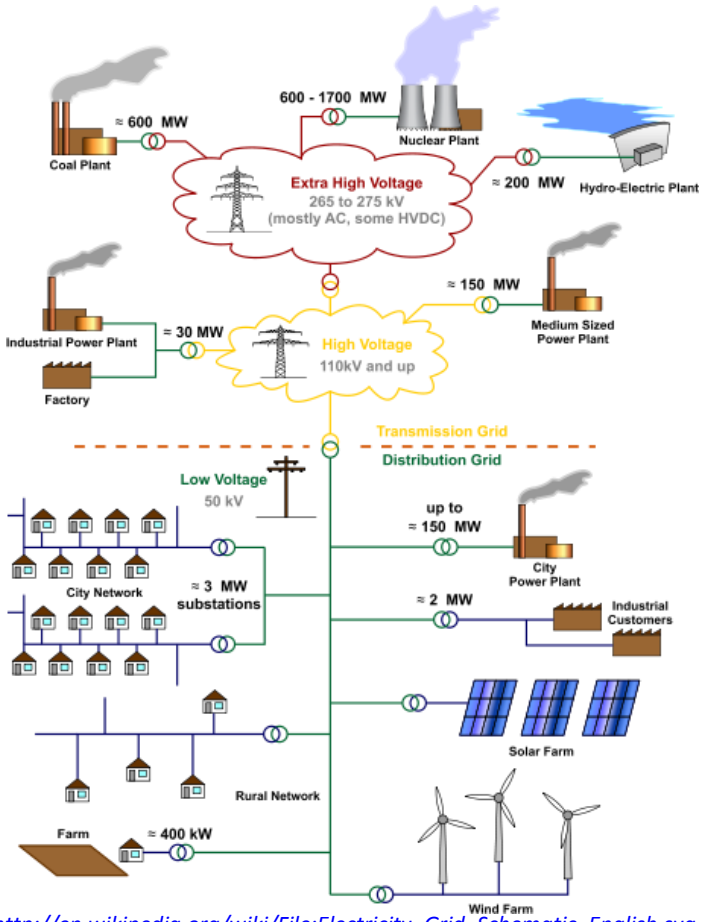
Building/Construction Manager
Description: Plan, direct, coordinate, or budget, usually through subordinate supervisory personnel, activities concerned with the construction and maintenance of structures, facilities, and systems.

Electrical Engineer
Description: Apply electrical theory and related knowledge to test and modify developmental or operational electrical machinery and electrical control equipment and circuitry in industrial or commercial plants.

Power Plant Supervisor – Nuclear Power
Description: Supervises and coordinates activities of workers engaged in operation and control of thermonuclear reactor, turbine generator, and auxiliary equipment at electric generating station.

Power Plant Technician
Description: Control, operate, or maintain machinery to generate electric power. Includes auxiliary equipment operators.

Mechanical Engineer
Description: Apply theory and principles of mechanical engineering to modify, develop, and test machinery and equipment under direction of engineering staff or physical scientists.



MBizon, http://en.wikipedia.org/wiki/File:Electricity_Grid_Schematic_English.svg, 9/1/2010. Used with permission.

PART 1 – EXPLORE

Do this for the first 20 minutes of class

Starter Question 3 minutes

What are the effects on power transmitted over long distances through power lines?

Perform these *Teacher Actions* ***Do these in the order indicated***	Expect this *Student Experience* ***You should see your students experience the following***
1. ENGAGE (3 minutes) Ask students the Starter Question. Facilitate a class discussion for five minutes and help the students take ownership of the lesson.	**ENGAGEMENT** Students take ownership while they are discussing a question that matters to them.
2. DIRECT (2 minutes) Direct students to log into Whyville, go to *WhyPower*, and then to *WhyPower Inside*, and then to *PowerLine Engineer*. Direct them to read the instructions for the *PowerLine* activities. NOTE: Avoid giving further directions. Let them explore individually and figure out for themselves what is going on, and how to be successful in the activities.	**EXPLORATION** Within three minutes of the start of the lesson, students are logged into Whyville and in the PowerLine activity, exploring the activity and learning what is important and how to be successful.
3. COACH (15 minutes) Wander around the room, encourage team members to help each other, and help the students if they cannot work through problems. Ask students what the activity is, what is important to succeed, and where they have additional questions.	

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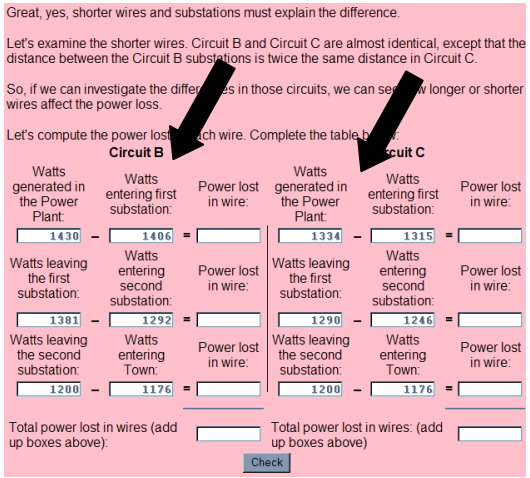
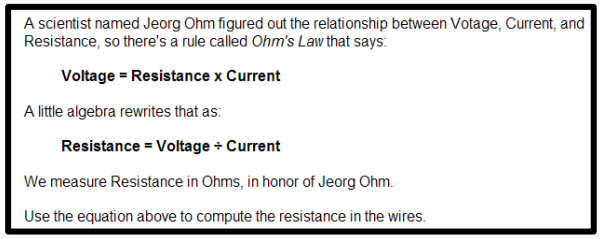
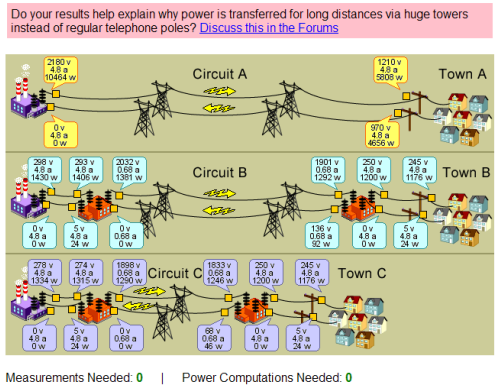
WHERE DO THE LESSONS APPEAR? Recognize where the core content shows up.







The data tables lead the students to discover the concepts of resistance and energy loss.	The line of questioning allows students to use deductive reasoning to discover Ohm's Law and apply the formula to the situations described in the map and data tables.	The questions posed to the students demonstrate understanding of the relationship between voltage, amperage, and power and urges them to discuss the concepts in the Whyville Forum.

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PART 2 – REFLECT

Do this for the next 10 minutes of class

	Perform these *Teacher Actions* *Do these in the order indicated*	Expect this *Student Experience* *You should see your students experience the following*
1.	**GATHER** Give students a one-minute warning that exploration time is almost over. Then, have them turn off their screens quickly.	**GATHER** Students wrap-up their self-guided exploration and turn their full attention to the discussion.
2.	**FACILITATE** Lead students to discuss the questions below. Resist any urge to give them the answers.	**REFLECT (group)** Students share their ideas and refine their ideas in large group discussion.

Questions

	Question	Expected Answer
1.	What is the PowerLine activity about?	Running power lines from power plants to homes and businesses. Measuring power, voltage, and amperage at different points in a power grid and calculating voltage drop.
2.	What is success in the activity?	Answering the questions and filling in the data tables correctly to earn the PowerLine Engineer badge.
3.	What do you need to know to succeed?	How to rearrange a formula to solve for a specific variable and how to add, subtract, multiply, and divide.
4.	What questions do you still have?	
5.	Beyond being graded, do you care about this? Does this topic affect your life?	
6.	Name a real world job that is like this job.	

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PART 3 – ACCOMPLISH

Do this for the next 15 minutes of class

	Perform these *Teacher Actions* ***Do these in the order indicated***	Expect this *Student Experience* ***You should see your students experience the following***
1.	**DIRECT** Tell the students that their goal is earn their PowerLine Engineer badge. NOTE: Some students may have earned the badges during the prior class period or during the Explore section.	**ACCOMPLISH** Students work independently to earn their badges. Those that already earned their badge help those who have not. They receive help from the teacher as needed.
2.	**CONNECT** As students finish and have no others to help, direct them to complete the CONNECT worksheet.	**CONNECT** Students complete the worksheet, demonstrating mastery of the relevant standards and understanding of real-world applications.

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Name	
Date	
Class Period	
Whyville ID	
What was this activity about?	
What did you need to know to succeed?	
What new questions did you think of while playing this activity?	
What is voltage drop?	
How do you calculate power?	
Name a real-world career that is related to what you learned today.	
Do you care about what you learned? Is it relevant to your life? Why or why not?	

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All TEKS listed are impacted by this lesson plan. **Boldfaced TEKS** represent the focus of the lesson plan.

TEKS: Career Investigation

(2) The student knows how to locate, analyze, and apply career information. The student is expected to:
- **(A) access career information using print and on-line resources to complete an educational and/or training plan for a career pathway;**
- (B) access career information using interviews with business and industry representatives to create a career resource file;

(6) The student knows the process of career planning. The student is expected to:
- (A) list and explain the steps in the decision-making process;
- (B) prepare an oral or written plan describing the specific factors considered in the decision-making process used to solve a simulated career problem;

(7) The student knows the importance of productive work habits and attitudes. The student is expected to:
- (B) list characteristics of an effective team member;
- **(C) work on a team to accomplish an assigned task; and**
- (D) write job scenarios demonstrating positive and negative employee/customer relations.

TEKS: Exploring Careers

1) The student explores personal interests and aptitudes as they relate to education and career planning. The student is expected to:
- **(D) research current and emerging fields related to personal interest areas;**
- (F) explore how career choices impact the balance between personal and professional responsibilities; and

(2) The student analyzes personal interests and aptitudes regarding education and career planning. The student is expected to:
- (C) develop and analyze tables, charts, and graphs related to career interests;
- **(D) determine the impact of technology on careers of personal interest; and**

(4) The student evaluates skills for personal success. The student is expected to:
- **(A) implement effective study skills for academic success;**
- **(C) use a problem-solving model and critical-thinking skills to make informed decisions;**
- **(D) use effective time-management and goal-setting strategies;**
- **(E) effectively use information and communication technology tools; and**

(5) The student recognizes the impact of career choice on personal lifestyle. The student is expected to:
- (A) prepare a personal budget reflecting the student's desired lifestyle;

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(7) The student develops skills for professional success. The student is expected to:

(E) explore and model characteristics necessary for professional success such as work ethics, integrity, dedication, perseverance, and the ability to interact with a diverse population; and

(F) complete activities using project- and time-management techniques.

(8) The student identifies and explores technical skills essential to careers in multiple occupations, including those that are high skill, high wage, or high demand. The student is expected to:

(A) complete actual or virtual labs to simulate the technical skills required in various occupations; and

(B) analyze the relationship between various occupations such as the relationship between interior design, architectural design, manufacturing, and construction on the industry of home building or the multiple occupations required for hospital administration.

TEKS: Career Portals

(1) The student explores one or more career clusters of interest. The student is expected to:

(A) identify the various career opportunities within one or more career clusters; and

(B) identify the pathways within one or more career clusters.

(2) The student explores pathways of interest within one or more career clusters. The student is expected to:

(A) investigate career opportunities within the pathways;

(B) explore careers of personal interest;

(4) The student explores the professional skills needed for college and career success. The student is expected to:

(E) identify professional associations affiliated with a specified program of study;

(F) employ effective leadership, teamwork, and conflict management;

TEKS: Mathematics

(1) Number, operation, and quantitative reasoning. The student understands that different forms of numbers are appropriate for different situations. The student is expected to:

(B) select and use appropriate forms of rational numbers to solve real-life problems including those involving proportional relationships;

(2) Number, operation, and quantitative reasoning. The student selects and uses appropriate operations to solve problems and justify solutions. The student is expected to:

(A) select appropriate operations to solve problems involving rational numbers and justify the selections;

(B) use appropriate operations to solve problems involving rational numbers in problem situations;

(C) evaluate a solution for reasonableness; and

(3) Patterns, relationships, and algebraic thinking. The student identifies proportional or non-proportional linear relationships in problem situations and solves problems. The student is expected to:

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(A) compare and contrast proportional and non-proportional linear relationships; and
(B) estimate and find solutions to application problems involving percents and other proportional relationships such as similarity and rates.

(4) Patterns, relationships, and algebraic thinking. The student makes connections among various representations of a numerical relationship. The student is expected to generate a different representation of data given another representation of data (such as a table, graph, equation, or verbal description).

(5) Patterns, relationships, and algebraic thinking. The student uses graphs, tables, and algebraic representations to make predictions and solve problems. The student is expected to:

(A) predict, find, and justify solutions to application problems using appropriate tables, graphs, and algebraic equations; and

(14) Underlying processes and mathematical tools. The student applies Grade 8 mathematics to solve problems connected to everyday experiences, investigations in other disciplines, and activities in and outside of school. The student is expected to:

(A) identify and apply mathematics to everyday experiences, to activities in and outside of school, with other disciplines, and with other mathematical topics;

(B) use a problem-solving model that incorporates understanding the problem, making a plan, carrying out the plan, and evaluating the solution for reasonableness;

(D) select tools such as real objects, manipulatives, paper/pencil, and technology or techniques such as mental math, estimation, and number sense to solve problems.

(15) Underlying processes and mathematical tools. The student communicates about Grade 8 mathematics through informal and mathematical language, representations, and models. The student is expected to:

(A) communicate mathematical ideas using language, efficient tools, appropriate units, and graphical, numerical, physical, or algebraic mathematical models; and

(B) evaluate the effectiveness of different representations to communicate ideas.

(16) Underlying processes and mathematical tools. The student uses logical reasoning to make conjectures and verify conclusions. The student is expected to:

(A) make conjectures from patterns or sets of examples and nonexamples; and

(B) validate his/her conclusions using mathematical properties and relationships.

TEKS: Science

(3) Scientific investigation and reasoning. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions and knows the contributions of relevant scientists. The student is expected to:

(A) in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student;

(B) use models to represent aspects of the natural world such as an atom, a molecule, space, or a geologic feature;

(C) identify advantages and limitations of models such as size, scale, properties, and materials;

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Blooms (Taxonomy):

X	Knowledge: arrange, define, duplicate, label, list, memorize, name, order, recognize, relate, recall, repeat, reproduce state.
X	Comprehension: classify, describe, discuss, explain, express, identify, indicate, locate, recognize, report, restate, review, select, translate
X	Application: apply, choose, demonstrate, dramatize, employ, illustrate, interpret, operate, practice, schedule, sketch, solve, use, write.
X	Analysis: analyze, appraise, calculate, categorize, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, test.
X	Synthesis: arrange, assemble, collect, compose, construct, create, design, develop, formulate, manage, organize, plan, prepare, propose, set up, write.
X	Evaluation: appraise, argue, assess, attach, choose compare, defend estimate, judge, predict, rate, core, select, support,

Instructional Strategies:

X	Identifying similarities and differences
X	Summarizing and note taking
X	Reinforcing effort and providing recognition
	Homework and practice
X	Nonlinguistic representations
X	Cooperative learning
X	Setting objectives and providing feedback
X	Generating and testing hypotheses
X	Cues, questions, and advanced organizers

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Sixth Grade

Subcategory	Standard ID	Standard Description
The Number System	6.NS.3	Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation.
Expressions and Equations	6.EE.2.C	Write, read, and evaluate expressions in which letters stand for numbers. c. Evaluate expressions at specific values of their variables. Include expressions that arise from formulas used in real-world problems. Perform arithmetic operations, including those involving wholenumber exponents, in the conventional order when there are no parentheses to specify a particular order (Order of Operations). For example, use the formulas V = s3 and A = 6 s2 to find the volume and surface area of a cube with sides of length s = 1/2.
Expressions and Equations	6.EE.6	Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.
Expressions and Equations	6.EE.7	Solve real-world and mathematical problems by writing and solving equations of the form x + p = q and px = q for cases in which p, q and x are all nonnegative rational numbers.

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Subcategory	Standard ID	Standard Description
Expressions and Equations	6.EE.9	Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. For example, in a problem involving motion at constant speed, list and graph ordered pairs of distances and times, and write the equation d = 65t to represent the relationship between distance and time.

Seventh Grade

Subcategory	Standard ID	Standard Description
The Number System	7.NS.2.A	Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. a. Understand that multiplication is extended from fractions to rational numbers by requiring that operations continue to satisfy the properties of operations, particularly the distributive property, leading to products such as (–1)(–1) = 1 and the rules for multiplying signed numbers. Interpret products of rational numbers by describing real-world contexts.
The Number System	**7.NS.2.C**	**Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. c. Apply properties of operations as strategies to multiply and divide rational numbers.**
The Number System	**7.NS.3**	**Solve real-world and mathematical problems involving the four operations with rational numbers.**

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Subcategory	Standard ID	Standard Description
Expressions and Equations	7.EE.3	Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. For example: If a woman making $25 an hour gets a 10% raise, she will make an additional 1/10 of her salary an hour, or $2.50, for a new salary of $27.50. If you want to place a towel bar 9 3/4 inches long in the center of a door that is 27 1/2 inches wide, you will need to place the bar about 9 inches from each edge; this estimate can be used as a check on the exact computation.
Expressions and Equations	**7.EE.4.A**	**Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. a. Solve word problems leading to equations of the form px + q = r and p(x + q) = r, where p, q, and r are specific rational numbers. Solve equations of these forms fluently. Compare an algebraic solution to an arithmetic solution, identifying the sequence of the operations used in each approach. For example, the perimeter of a rectangle is 54 cm. Its length is 6 cm. What is its width?**

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Eighth Grade

Subcategory	Standard ID	Standard Description
Functions	8.F.4	Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x, y) values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values.

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