Practices for Science Investigation
Kindergarten-Physics Progression

2010 *Science Standards of Learning*

Introduction[1] | Proficiency | Advanced Mastery

OBSERVING	K	1	2	3	4	5	6	LS	PS	ES	BI	CH	PH
Basic characteristics or properties of objects are identified by direct observation. (K.1a)			1										
Observations are made from multiple positions to achieve different perspectives. (K.1b)													
The senses are used to observe differences in physical properties. (1.1a)													
Observations are made from multiple positions to achieve a variety of perspectives and are repeated to ensure accuracy. (1.1b)													
Simple tools are used to enhance observations. (1.1d)													
Observations and predictions are made and questions are formed. (2.1a)													
Observation is differentiated from personal interpretation. (2.1b)													
Observations are repeated to ensure accuracy. (2.1c)													
Observations are made and are repeated to ensure accuracy. (3.1a)				2									
Distinctions are made among observations, conclusions, inferences, and predictions. (4.1a)													
Observations are made involving fine discrimination between similar objects and organisms. (6.1a)									3				
Observations of living things are recorded in the lab and in the field. (BIO.1a)											4		
Instruments are selected and used to extend observations and measurements of mass, volume, temperature, heat exchange, energy transformations, motion, fields, and electric charge. (PH.1b)													5

1. Proficient performance on an introduced skill in routine classroom tasks and performances is expected by the end of grade-level/course instruction unless indicated by multiple introductory year blocks.
2. The standard segment 3.1a repeats the previous segment, 2.1c, which introduces the disposition of repeated trials. Therefore this is not a newly introduced skill, and grade-appropriate proficient performance for this basic skill is expected by the end of third grade.
3. Fine discrimination is somewhat discipline specific depending on the complexity of the subject matter and the experiences of the observer. For example, discerning the difference between two somewhat similar rocks (5.5b) or organisms (5.7a) requires honing observational skills (practice) and deeper knowledge of specific descriptive terminology.
4. The skill was introduced in standard segment 6.1 a. The skill is used in a discipline-specified context in this high school course, with the expectation that students will have rigorous inquiry experiences in the field/laboratory setting, building work and postsecondary education readiness.
5. The additional context of measuring fields and electric charges, usually reserved for high school physics, qualifies this as an introduction-level skill.

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Introduction[1]	Proficiency	Advanced Mastery

CLASSIFYING AND SEQUENCING	GRADE/COURSE												
	K	1	2	3	4	5	6	LS	PS	ES	BI	CH	PH
A set of objects is sequenced according to size. (K.1c)	[1]												
A set of objects is separated into two groups based on a single physical characteristic. (K.1d)													
Objects or events are classified and arranged according to characteristics or properties. (1.1c)													
Two or more characteristics or properties are used to classify items. (2.1d)													
Objects with similar characteristics or properties are classified into at least two sets and two subsets. (3.1c)													
Natural events are sequenced chronologically. (3.1d)													
Objects or events are classified and arranged according to characteristics or properties. (4.1b)					[2]								
Items such as rocks, minerals, and organisms are identified using various classification keys. (5.1a)													
A classification system is developed based on multiple attributes. (LS.1b)													

1. Proficient performance on an introduced skill in routine classroom tasks and performances is expected by the end of grade-level/course instruction unless indicated by multiple introductory year blocks.
2. This standard segment is introduced as 1.1c and is repeated here because of its crucial place in the classification skills hierarchy.

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Introduction[1] | Proficiency | Advanced Mastery

COMMUNICATING	K	1	2	3	4	5	6	LS	PS	ES	BI	CH	PH
	GRADE/COURSE												
Observations are recorded. (K.1h)			[1]										
Picture graphs are constructed. (K.1i)													
Objects are described both pictorially and verbally. (K.1k)													
Observations and data are recorded, analyzed, and communicated orally and with simple graphs, pictures, written statements, and numbers. (1.1i) (*Analyzing Data*)*													
Data are collected and recorded, and bar graphs are constructed using numbered axes. (2.1h)													
Observations and data are communicated. (2.1k)													
Data are gathered, charted, graphed, and analyzed. (3.1h)													
Data are communicated. (3.1k)													
Data are collected, recorded, analyzed, and displayed using bar and basic line graphs. (4.1i)													
Data are communicated with simple graphs, pictures, written statements, and numbers. (4.1k)													
Data are collected, recorded, analyzed, and communicated using proper graphical representations and metric measurements. (5.1g) (*Analyzing Data*)													
Data are collected, recorded, analyzed, and reported using metric measurements and tools. (6.1g) (*Measuring*)													
Data are analyzed and communicated through graphical representation. (6.1h) (*Analyzing Data*)													
Data are organized into tables showing repeated trials and means. (LS.1a)													
Data are organized, communicated through graphical representation, interpreted, and used to make predictions. (LS.1h)													
Numbers are expressed in scientific notation where appropriate. (PS.1e)									[2]				
Data tables showing the independent and dependent variables, derived quantities, and the number of trials are constructed and interpreted. (PS.1g) (*Analyzing Data*)													
Data tables for descriptive statistics showing specific measures of central tendency, the range of the data set, and the number of repeated trials are constructed and interpreted. (PS.1h) (*Analyz. Data*)									[3]				
Frequency distributions, scatterplots, line plots, and histograms are constructed and interpreted. (PS.1i)									[4]				

Introduction[1]	Proficiency	Advanced Mastery	GRADE/COURSE

COMMUNICATING	K	1	2	3	4	5	6	LS	PS	ES	BI	CH	PH
Experimental results are presented in appropriate written form. (PS.1l)													
Scales, diagrams, charts, graphs, tables, imagery, models, and profiles are constructed and interpreted. (ES.1c) (*Modeling, Analyzing Data*)										[5]			
Appropriate technology including computers, graphing calculators, and probeware, is used for gathering and analyzing data, communicating results, modeling concepts, and simulating experimental conditions. (BIO.1i) (*Modeling, Analyzing Data*)													
Research utilizes scientific literature. (BIO.1j)													
Accurate recording, organization, and analysis of data through repeated trials. (CH.1e) (*Analyzing Data*)													
Use of appropriate technology including computers, graphing calculators, and probeware, for gathering data, communicating results, and using simulations to model concepts. (CH.1h) (*Modeling*)												[6]	
Construction and defense of a scientific viewpoint. (CH.1i)													
The components of a system are defined. (PH.1a)													
Information is recorded and presented in an organized format. (PH.1c)													
Appropriate technology, including computers, graphing calculators, and probeware, is used for gathering and analyzing data and communicating results. (PH.1g) (*Analyzing Data*)													
A description of a physical problem is translated into a mathematical statement in order to find a solution. (PH.2a)													
Construction and defense of a scientific viewpoint. (PH.3e)													

1. Proficient performance on an introduced skill in routine classroom tasks and performances is expected by the end of grade-level/course instruction unless indicated by multiple introductory year blocks.
2. Scientific notation is introduced in the Grade 7 Mathematics SOL, 7.1b (2009).
3. Measures of central tendency are introduced in the Grade 5 Mathematics SOL, 5.16a.
4. Histograms are introduced in the Grade 7 Mathematics SOL, 7.11a, 7.11b.
5. Imagery and profiles are introduced in this segment.
6. The Computer Technology SOL introduces the use of hand-held technologies in the middle grades, e.g., C/T 6-8.6 and 6-8.8.

*When a skill is repeated, the additional location is indicated by parentheses.

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Introduction[1] | Proficiency | Advanced Mastery

MEASURING	K	1	2	3	4	5	6	LS	PS	ES	BI	CH	PH
Nonstandard units are used to measure the length, mass, and volume of common objects. (K.1e)		[1]											
Length, mass, volume, and temperature are measured using nonstandard units. (1.1e)													
Length, volume, mass, and temperature are measured in metric units and standard English units using the proper tools. (2.1e)													
Time is measured using the proper tools. (2.1f)													
Length, volume, mass, and temperature are estimated and measured in metric and standard English units using proper tools and techniques. (3.1e)													
Time is measured to the nearest minute using proper tools and techniques. (3.1f)													
Appropriate instruments are selected and used to measure length, mass, volume, and temperature in metric units. (4.1c)													
Appropriate instruments are selected and used to measure elapsed time. (4.1d)													
Estimates are made and accurate measurements of length, mass, volume, and temperature are made in metric units using proper tools. (5.1b)													
Estimates are made and accurate measurements of elapsed time are made using proper tools. (5.1c)													
Precise and approximate measurements are recorded. (6.1b)													
Data are collected, recorded, analyzed, and reported using appropriate metric measurements and tools. (6.1g) (*Communicating*)*													
Triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, and probeware are used to gather data. (LS.1c)													
Length, mass, volume, density, temperature, weight, and force are accurately measured. (PS.1b)									[2]				
Conversions are made among metric units, applying appropriate prefixes. (PS.1c)													
Triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, probeware, and spring scales are used to gather data. (PS.1d)													
Volume, area, mass, elapsed time, direction, temperature, pressure, distance, density, and changes in elevation/depth are calculated utilizing the most appropriate tools. (ES.1a)										[3]			
Mathematical manipulations including SI units, scientific notation, linear equations, graphing, ratio and proportion, significant digits, and dimensional analysis. (CH.1g) (*Data Analysis*)													
Instruments are selected and used to extend observations and measurements. (PH.1b)													

Introduction[1]	Proficiency	Advanced Mastery	GRADE/COURSE												
MEASURING			K	1	2	3	4	5	6	LS	PS	ES	BI	CH	PH
The limitations of measured quantities are recognized through the appropriate use of significant figures or error ranges; (PH.1e)															

1. Proficient performance on an introduced skill in routine classroom tasks and performances is expected by the end of grade-level/course instruction unless indicated by multiple introductory year blocks.
2. A quantitative concept of force is introduced to concepts measured.
3. The concept of contours for measuring elevation and depth is introduced. High-performing and advanced students should have some experience with contours by the end of sixth grade.

*When a skill is repeated, the additional location is indicated by parentheses.

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Introduction[1]	Proficiency	Advanced Mastery

PREDICTING	K	1	2	3	4	5	6	LS	PS	ES	BI	CH	PH
	GRADE/COURSE												
Observations and predictions are made for an unseen member in a sequence of objects. (K.1f)													
Predictions are made based on patterns of observations. (1.1h)													
Predictions are formulated using a variety of sources of information. (3.1b)													
Predictions and inferences are made, and conclusions are drawn based on data from a variety of sources. (4.1e)													
Predictions are made using patterns from data collected, and simple graphical data are generated. (5.1h)													
A method is devised to test the validity of predictions and inferences. (6.1e)								1					
Data are organized, communicated through graphical representation, interpreted, and used to make predictions. (LS.1h)								2					
Interpolated, extrapolated, and analyzed trends are used to make predictions. (PH.2d) (*Analyzing Data*)*													3

1. Proficient performance on an introduced skill in routine classroom tasks and performances is expected by the end of grade-level/course instruction unless indicated by multiple introductory year blocks.
2. All the prerequisite skills are found in earlier grades in this scope and sequence grid and in the "Communicating" grid.
3. The operations defining "interpolation" and "extrapolation" are formally presented in Algebra I.

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Introduction[1]	Proficiency	Advanced Mastery

HYPOTHESIZING	K	1	2	3	4	5	6	LS	PS	ES	BI	C H	PH
Question is developed and predictions are made from one or more observations. (K.1g)				[1]									
Question is developed from one or more observations. (1.1g)													
Questions are developed to formulate hypotheses. (3.1g)													
Hypotheses are developed as cause and effect relationships. (4.1h)													
Hypotheses are formed from testable questions. (5.1d)													
Hypotheses are stated in ways that identify the independent and dependent variables. (6.1d)													
Variables are controlled to test hypotheses, and trials are repeated. (LS.1g) (*Variables/Experimentation*)*								[2]					
Hypotheses are formulated based on direct observations and information from scientific literature. (BIO.1b)											[3]		
Differentiation is made between a scientific hypothesis, theory, and law. (BIO.1k)													
Analy(ze) scientific sources to develop and refine research hypotheses. (PH.3a)													

1. Proficient performance on an introduced skill in routine classroom tasks and performances is expected by the end of grade-level/course instruction unless indicated by multiple introductory year blocks.
2. Constants and manipulating variables are introduced in 4.1g and 6.1f, respectively.
3. Precursor skills are introduced in 1.1g and 3.1g.

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Introduction[1] Proficiency Advanced Mastery

INFERRING	GRADE/COURSE												
	K	1	2	3	4	5	6	LS	PS	ES	BI	CH	PH
Inferences are made and conclusions are drawn about familiar objects and events. (1.1f)			[1]										
Conclusions are drawn. (2.1j)													
Inferences are made and conclusions are drawn. (3.1j)													
Predictions and inferences are made, and conclusions are drawn based on data from a variety of sources. (4.1e) (*Predicting*)*													
Inferences are made and conclusions are drawn. (5.1i)													
Conclusions are formed based on recorded quantitative and qualitative data. (BIO.1e) (*Analyzing Data*)													

1. Proficient performance on an introduced skill in routine classroom tasks and performances is expected by the end of grade-level/course instruction unless indicated by multiple introductory year blocks.

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Introduction[1]	Proficiency	Advanced Mastery

USING VARIABLES IN EXPERIMENTATION	GRADE/COURSE												
	K	1	2	3	4	5	6	LS	PS	ES	BI	CH	PH
Simple investigations and experiments are conducted to answer questions. (1.1j)				[1]									
Conditions that influence a change are identified and inferences are made. (2.1g)													
Independent and dependent variables are identified. (4.1f)													
Constants in an experimental situation are identified. (4.1g)													
Independent and dependent variables are identified. (5.1e)													
Constants in an experimental situation are identified. (5.1f)													
One variable is manipulated over time, using many repeated trials. (6.1f)													
Sources of experimental error are identified. (LS.1e)													
Dependent variables, independent variables, and constants are identified. (LS.1f)													
Variables are controlled to test hypotheses, and trials are repeated. (LS.1g) (*Hypothesizing*)*													
Independent and dependent variables, constants, controls, and repeated trials are identified. (PS.1f)													
Research methods are used to investigate practical problems and questions. (PS.1k)													
Variables are manipulated with repeated trials. (ES.1e)													
Variables are defined and investigations are designed to test hypotheses. (BIO.1c)													
Sources of error inherent in experimental design are identified and discussed. (BIO.1f)													
Designated laboratory techniques (*are implemented*). (CH.1a)													
(*Verifiable observations and data are obtained through the*) manipulation of multiple variables, using repeated trials. (CH.1d)													
The limitations of the experimental apparatus and design are recognized. (PH.1d)													

1. Proficient performance on an introduced skill in routine classroom tasks and performances is expected by the end of grade-level/course instruction unless indicated by multiple introductory year blocks.

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Introduction[1] Proficiency Advanced Mastery

INTERPRTING, ANALYZING, AND EVALUATING DATA	GRADE/COURSE												
	K	1	2	3	4	5	6	LS	PS	ES	BI	CH	PH
Unusual or unexpected results in an activity are recognized. (K.1j)				[1]									
Observations and data are recorded, analyzed, and communicated orally and with simple graphs, pictures, written statements, and numbers. (1.1i) (*Communicating*)*													
Data are analyzed, and unexpected or unusual quantitative data are recognized. (2.1i)													
Unexpected or unusual quantitative data are recognized. (3.1i)													
Numerical data that are contradictory or unusual in experimental results are recognized. (4.1j)													
Data are collected, recorded, analyzed, and communicated using proper graphical representations and metric measurements. (5.1g) (*Communicating*)													
Data are analyzed and communicated through graphical representation. (6.1h) (*Communicating*)													
Patterns are identified in data and are interpreted and evaluated. (LS.1i)													
Data tables showing the independent and dependent variables, derived quantities, and the number of trials are constructed and interpreted. (PS.1g) (*Communicating*)													
Data tables for descriptive statistics showing specific measures of central tendency, the range of the data set, and the number of repeated trials are constructed and interpreted. (PS.1h) (*Communicating*)													
Frequency distributions, scatterplots, line plots, and histograms are constructed and interpreted. (PS.1i) (*Communicating*)													
Valid conclusions are made after analyzing data. (PS.1j)													
Technologies, including computers, probeware, and geospatial technologies, are used to collect, analyze, and report data and to demonstrate concepts and simulate experimental conditions. (ES.1b) (*Communicating, Modeling*)										[2]			
Scales, diagrams, charts, graphs, tables, imagery, models, and profiles are constructed and interpreted. (ES.1c) (*Communicating*)										[3]			
Graphing and arithmetic calculations are used as tools in data analysis. (BIO.1d)													
Conclusions are formed based on recorded quantitative and qualitative data. (BIO.1e) (*Inferring*)													
Validity of data is determined. (BIO.1g)													
Appropriate technology including computers, graphing calculators, and probeware, is used for gathering and analyzing data, communicating results, modeling concepts, and simulating experimental conditions. (BIO.1i) (*Communicating, Modeling*)													

Introduction[1]	Proficiency	Advanced Mastery	GRADE/COURSE

INTERPRTING, ANALYZING, AND EVALUATING DATA	K	1	2	3	4	5	6	LS	PS	ES	BI	CH	PH
Alternative scientific explanations and models are recognized and analyzed. (BIO.1l)													
Accurate recording, organization, and analysis of data through repeated trials. (CH.1e) (*Communicating*)													
Mathematical and procedural error analysis (*is performed*). (CH.1f)													
Mathematical manipulations including SI units, scientific notation, linear equations, graphing, ratio and proportion, significant digits, and dimensional analysis. (CH.1g) (*Measuring*)													
Models and simulations are used to visualize and explain phenomena, to make predictions from hypotheses, and to interpret data. (PH.1f) (*Modeling*)													
Appropriate technology, including computers, graphing calculators, and probeware, is used for gathering and analyzing data and communicating results. (PH.1g) (*Communicating*)													
Relationships between physical quantities are determined using the shape of a curve passing through experimentally obtained data. (PH.2b)													
The slope of a linear relationship is calculated and includes appropriate units. (PH.2c)													
Interpolated, extrapolated, and analyzed trends are used to make predictions. (PH.2d) (*Predicting*)													
Situations with vector quantities are analyzed utilizing trigonometric or graphical methods. (PH.2e)													

1. Proficient performance on an introduced skill in routine classroom tasks and performances is expected by the end of grade-level/course instruction unless indicated by multiple introductory year blocks.
2. The Computer Technology SOL introduces the use of hand-held technologies in the middle grades, e.g., C/T 6-8.6 and 6-8.8. Geospatial technology is formally introduced in Earth science.
3. Imagery and profiles are introduced in this segment.

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Introduction[1]	Proficiency	Advanced Mastery

DESIGNING, CONSTRUCTING, AND INTERPRETING MODELS	GRADE/COURSE										
	2	3	4	5	6	LS	PS	ES	BI	CH	PH
Simple physical models are designed and constructed to clarify explanations and show relationships. (2.1l)		[1]									
Models are designed and built. (3.1l)											
Models are constructed to clarify explanations, demonstrate relationships, and solve needs. (4.1l)											
Models are constructed to clarify explanations, demonstrate relationships, and solve needs. (5.1j)											
Scale models are used to estimate distance, volume, and quantity. (6.1c)											
Models and simulations are designed and used to illustrate and explain phenomena and systems. (6.1i)											
Models and simulations are constructed and used to illustrate and explain phenomena. (LS.1d)											
Models and simulations are constructed and used to illustrate and explain phenomena. (PS.1m)											
Technologies, including computers, probeware, and geospatial technologies, are used to collect, analyze, and report data and to demonstrate concepts and simulate experimental conditions. (ES.1b) (*Communicating, Analyzing Data*)*											
Maps and globes are read and interpreted, including location by latitude and longitude. (ES.1d)											
Appropriate technology including computers, graphing calculators, and probeware, is used for gathering and analyzing data, communicating results, modeling concepts, and simulating experimental conditions. (BIO.1i) (*Communicating, Analyzing Data*)									[2]		
Alternative scientific explanations and models are recognized and analyzed. (BIO.1l) (*Analyzing Data*)											
Use of appropriate technology including computers, graphing calculators, and probeware, for gathering data, communicating results, and using simulations to model concepts. (CH.1h) (*Communicating*)											
Models and simulations are used to visualize and explain phenomena, to make predictions from hypotheses, and to interpret data. (PH.1f) (*Analyzing Data*)											

1. Proficient performance on an introduced skill in routine classroom tasks and performances is expected by the end of grade-level/course instruction unless indicated by multiple introductory year blocks.
2. The Computer Technology SOL introduces the use of hand-held technologies in the middle grades, e.g., C/T 6-8.6 and 6-8.8.

*When a skill is repeated, the additional location is indicated by parentheses.