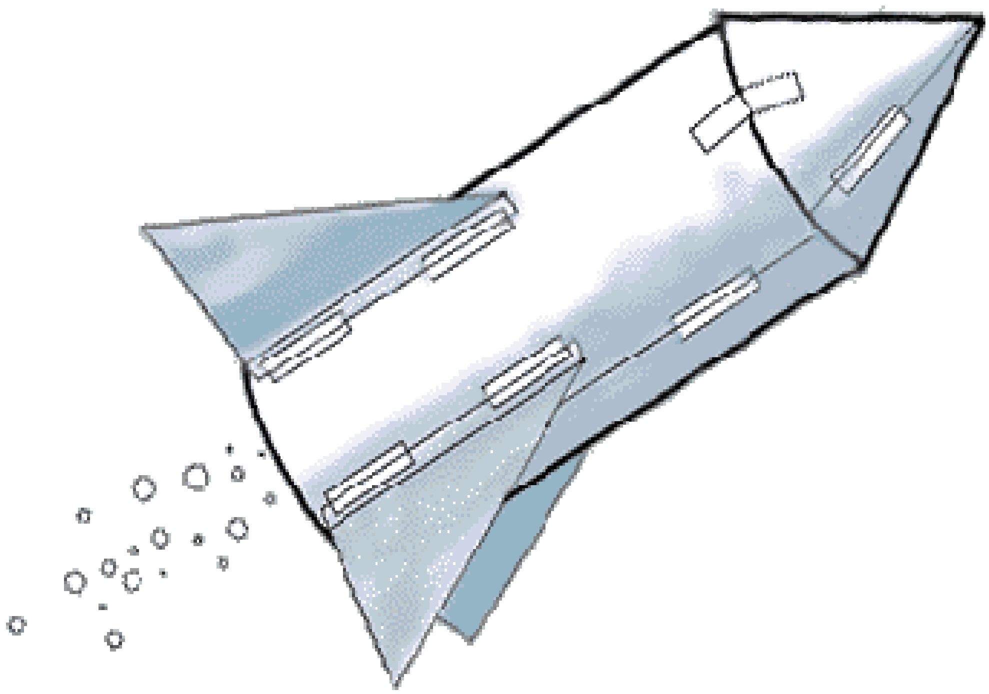
# STEM CIP

**Science/Technology/Engineering/Mathematics**
**Curriculum Integration Project**

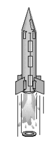


# 3-2-1 Lift Off

An Upper Elementary STEM Module

## Teacher's Guide

CurrTech Integrations

# 3-2-1 Lift Off 

## A Study of Force, Motion, Change of Matter, and Transfer of Energy

## Teacher's Guide

Written by

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# Introduction to STEM-CIP

**STEM-CIP**

**Science, Technology, Engineering, Mathematics-Curriculum Integration Project (STEM-CIP)** is an innovative approach to the design of curriculum and instructional materials in which the disciplines of science, technology, engineering, and mathematics are taught as one, rather than being distinct and separate as in the past. The natural connections among the four disciplines, which have always been there in the past in research labs and professional work, have not traditionally been emphasized in the design and process of present day education. The (upper elementary, middle and high school) modules of the STEM Curriculum Integration Project have been designed to engage students in stimulating, authentic, and contemporary problem-based STEM scenarios involving the life, physical, environmental, and earth/space sciences, technology and engineering, and mathematics. Drawing from the best in STEM pedagogy, the STEM-CIP modules provide students with the opportunity to learn age appropriate concepts, skills, and processes and to acquire STEM attitudes and "habits of mind."

**Curriculum Design Template**

All modules within STEM-CIP have been designed using principals of *Understanding by Design* (Wiggins and McTighe, 1998). *Understanding by Design (UbD)* is a well-known curriculum design process used to write units (modules of instruction) in a three-stage process–Desired Results, Assessment Evidence, and the Learning Plan. Many state departments of education, colleges and universities, and school systems advocate the use of *Understanding by Design* as a contemporary planning process for teaching and assessing state standards.

Many authors, among them Reeves (2003), Marzano, Pickering, and McTighe (1993), Lantz (2004), and Educators in Connecticut's Pomperaug Regional School District 15 (1996), have been proponents of performance-based assessment in which students must demonstrate what they know and can do through the completion of meaningful performance tasks. All modules within STEM-CIP present opportunities for students to engage in performance-based tasks and assessments, along with more traditional forms of assessment, such as selected response items.

**5 E Teaching, Learning, and Assessing Cycle**

A modified 5E teaching, learning, and assessing cycle, incorporated into all STEM-CIP modules, is based upon research findings about how students learn science. These findings indicate that students learn best when they have an opportunity to engage in explorations in a hands-on/minds-on environment in which they make and pose explanations for their discoveries. Engagement, Exploration, Explanation, Elaboration, and Evaluation are the recursive phases of the 5E teaching, learning, and assessing cycle.

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**Levels of Inquiry**

The National Science Education Standards, the National Council of Teachers of Mathematics Standards, the National Education Technology Standards for Students, and the Standards for Technological Literacy used in STEM-CIP modules call for teaching, implementing, and assessing student understanding of inquiry throughout the curriculum. As a result, four scaffolded levels of inquiry are included in most modules, starting with the most structured form - confirmatory inquiry, moving on to structured inquiry, then to guided inquiry, and finally to open inquiry. As students learn the skills and processes, and the content of inquiry, they are challenged by activities that become increasingly more open. The PowerPoint Teacher's Guide includes much more information about these four levels of inquiry and their implementation.

**Mathematics in STEM-CIP Modules**

One of the goals of STEM-CIP is to develop mathematical power for all students through an integration of science, technology, engineering and mathematics. Exemplary STEM curriculum modules should include performance tasks that engage students and deepen their understandings of mathematics and its applications, and at the same time promote the investigation and growth of mathematical ideas. A key question that is addressed in all STEM-CIP modules is "What enabling mathematical knowledge (facts, concepts and principles) and skills (procedures) will students need to perform effectively and achieve desired results (Stage One of UbD)."

Mathematics data on student performance from STEM-CIP modules provide mathematics teachers and curriculum designers a way to sequence mathematics standards and indicators and to plan instructional strategies. The disaggregated mathematics data from STEM-CIP provide answers to the sequence of mathematical units and also generate questions about a school district's math curriculum.

Questions that a district may need to address are:

- How do we sequence our mathematics curriculum because our mathematics text was not written in the same order?
- What are the strengths and weaknesses of our mathematics students?
- Although prior knowledge and skills were taught, some students have not demonstrated proficiency. Why?
- What type of remediation models was used?
- What type of enrichment model was used?
- What types of professional development needs were identified?
- How does STEM-CIP mathematics data compare with district milestone/benchmark data?
- What other resources are needed to "enable" our students?

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**Assessment of Student Work**

Formative and summative performance-based assessments have been thoughtfully sequenced and scaffolded to provide ample opportunities for students, teachers, parents, and others to assess student progress. An end of module summative assessment contains selected and constructed response items.

Extensive rubrics are provided for open-ended, performance-based questions and other performances that cannot be scored using typical right or wrong multiple choice items. In addition, most activities within STEM-CIP contain an end-of-activity evaluation called “Check Your Understanding” which consists of selected response items that lend themselves to the use of Student Response Systems for ease of scoring and immediate feedback on student understanding. Each activity within the modules is accompanied by scoring tools, including a variety of field-tested and National Science Teachers Association (NSTA) endorsed performance list, holistic, and analytical rubrics.

**Teacher’s Guide (TG)**

The Teacher’s Guide (TG) provides much detail about implementing the module. A matrix of standards, consisting of the National Science Education Standards, the National Council of Teachers of Mathematics Standards, the National Education Technology Standards for Students, and the Standards for Technological Literacy, along with assessment evidence for each standard is provided for the teacher. Enduring understandings, essential questions, an overview of the learning plan, and implementation hints for the module are provided as well. Each activity contains additional information about the phases of the 5E cycle, the level of inquiry, and what skills and processes the students will use during that activity.

**Student Curriculum Module (SCM)**

There are three components for students. The first of these is known as the Student Curriculum Module (SCM) which is non-consumable. The SCM, an electronic and reproducible component, serves as the primary text material for the student. As a result, the reading and comprehension levels of the SCM are carefully controlled. Using the SCM, the students engage in STEM problem-based tasks, acting as scientists, engineers, and mathematicians in designing, conducting, and communicating results of their research.

**Student Data and Response Booklet (SDRB)**

The second of the three student components is the Student Data and Response Booklet (SDRB). The SDRB is a consumable companion piece that parallels the SCM and provides a permanent record of student work.

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**End-of-Module Test**

The third student component is a summative assessment for the entire module. Answers to the test and scoring rubrics are included in the TG.

**Electronic Formats**

The TG, SCM, SDRB, and Module Assessment are available in two formats—PDF and Microsoft Word. The PDF files are smaller and easier to open and print. PDF requires Acrobat Reader. Changes to the PDF files cannot be made without Adobe Acrobat software; however, changes can be made in the Word documents. The SDRB and Module Assessment were created in Microsoft Word and are easily edited.

The TG and SCM were created in Microsoft Word using "InfoMap" software. Information Mapping is a trademarked method to write and structure information. This allows finding and following information much easier. More information about Information Mapping can be found online at www.infomap.com .

**Interactive Classroom Component**

Each activity within the SCM is accompanied by a PowerPoint presentation for the teacher which allows for the use of interactive, digital presentation technologies. This component provides both the novice and expert teacher with consistent high quality implementation strategies which lend themselves well to contemporary interactive technologies (e.g., e-textbooks, Internet use, digital libraries, student response systems, whiteboards, tablets, and document cameras). These interactive strategies are explicitly written into most activities of every module.

**Teacher-Friendly**

Every effort has been made to design the STEM CIP modules to be as teacher-friendly as possible, whether the teacher is a novice or an expert in teaching STEM. The novice teacher can pick up the module and teach it exactly as it was designed and in the process still provide a high quality instructional program. The expert teacher who knows about additional resources, materials, and instructional techniques can incorporate them into the module, as everything is provided in a digital format and is easily modified for both present and future use.

**Field-Tested**

Significant portions of the modules within STEM-CIP have been field-tested and reviewed by classroom teachers within the metropolitan Washington, DC and Baltimore areas, with their feedback being used to make final revisions.

# Overview of 3-2-1 Lift Off – Stage One of UbD (Desired Results)

**Desired Results**

**National Science Education Standards Grades 5-8, (NRC, 1996)**

Standard A: As a result of activities in grades 5-8, all students should develop abilities necessary to do scientific inquiry and understandings about scientific inquiry.

Standard B: As a result of activities in grades 5-8, all students should develop an understanding of properties and changes of properties in matter, motion and forces, and transfer of energy.

Standard E: As a result of activities in grades 5-8, all students should develop abilities of technological design and understandings about science and technology.

**National Council of Teachers of Mathematics Standards, Grades 5-8, (NCTM, 1989)**

Standard 9: Algebra Standard – In grades 5-8, the mathematics curriculum should include exploration of algebraic concepts and processes so that students can:

- Understand the concepts of variable, expression and equation.
- Represent situations and number patterns with tables, graphs, verbal rules and equations and explore the interrelationships of these representations.
- Analyze tables and graphs to identify properties and relationships.

Standard 10: Statistics – In grades 5-8, the mathematics curriculum should include exploration of statistics in real-world situations so that students can:

- Systematically collect, organize and describe data.
- Construct, read and interpret tables, charts and graphs.
- Make inferences and convincing arguments that are based on data analysis.
- Develop and appreciation for statistical methods as powerful means for decision making.

Standard 12: Geometry – In grades 5-8, the mathematics curriculum should include the study of the geometry of one, two and three dimensions in a variety of situations so that students can:

- Visualize and represent geometric figures with special attention to developing spatial sense.
- Represent and solve problems using geometric models.

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## Overview of 3-2-1 Lift Off – Stage One of UbD (Desired Results),
Continued

**Desired Results** (continued)

**National Council of Teachers of Mathematics Standards, Grades 5-8, (NCTM, 1989)**

Standard 13: Measurement – In grades 5-8, the mathematics curriculum should include extensive concrete experiences using measurement so that students can:

- Extend their understanding of the process of measurement.
- Estimate, make and use measurements to describe and compare phenomena.
- Select appropriate units and tools to measure to the degree of accuracy required in a particular situation.
- Extend their understanding of the concepts of perimeter, area, volume, angle measure, capacity, and weight and mass.
- Develop the concepts of rates and other derived and indirect measurements.
- Develop formulas and procedures for determining measures to solve problems.

**National Education Technology Standards for Students—ISTE, 1998, 2007**

<u>Creativity and Innovation Standard</u> – Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. Students:
(a) apply existing knowledge to generate new ideas, products, or processes.
(b) use models and simulations to explore complex systems and issues.

<u>Research and Information Fluency Standard</u> – Students apply digital tools to gather, evaluate, and use information. Students:
(a) plan strategies to guide inquiry.
(b) locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
(d) process data and report data.

<u>Critical Thinking, Problem-Solving, and Decision-Making Standard</u> – Students use critical thinking skills to plan and conduct research, manage projects, solve problems and make informed decisions using appropriate digital tools and resources. Students:
(b) plan and manage activities to develop a solution or complete a project.
(c) collect and analyze data to identify solutions and/or make informed decisions.

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**Desired Results** (continued)

**Standards for Technological Literacy, Grades 3-5 (ITEA, 2007)**

Core Concepts of Technology
G. When parts of a system are missing, it may not work as planned.
J. Materials have many different properties.
I. Requirements are the limits to designing or making a product or system.

Relationships Among Technologies and Other Fields
B. Technologies are often combined.
C. Various relationships exist between technology and other fields of study.

Attributes of Design
C. The design process is a purposeful method of planning a practical solution to problems.

Engineering Design
C. The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.
E. Models are used to communicate and test design ideas and processes.

Other Problem Solving Approaches
E. The process of experimentation, which is common in science, can also be used to solve technological problems.

Assess the Impact of Products and Systems
F. Test and evaluate the solutions for the design problem.
G. Improve the design solutions.

Use and Maintain Technological Products and Systems
D. Follow step-by-step directions to assemble a product.
E. Select and safely use tools, products, and systems for specific tasks.
F. Use computers to access and organize information.

Energy and Power Technologies
C. Energy comes in different forms.
D. Tools, machines, products, and systems use energy in order to do work.

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## Overview of 3-2-1 Lift Off – Stage One of UbD (Desired Results), Continued

| | |
|---|---|
| **Enduring Understandings** | Students will understand that:<br>• Science, Technology, Engineering, and Mathematics work in concert to answer contemporary questions and solve problems.<br>• Inquiry in STEM (Science, Technology, Engineering, and Mathematics) is based upon well-designed investigations.<br>• The two disciplines known as science and engineering have similarities, differences, and relationships.<br>• There is often a conversion of energy between potential and kinetic energy and friction acts in concert with the two.<br>• There are many factors that affect the rate of chemical reactions. |
| **Essential Questions** | • What is the acronym STEM and why is it important in today's world?<br>• What is a well-designed STEM investigation?<br>• What properties distinguish science from engineering?<br>• How do energy conversions impact the natural and/or designed systems?<br>• What factors can alter the rate of chemical reactions in natural and designed systems? |
| **Students will know…** | • The role of variables in investigations.<br>• What distinguishes a physical change from a chemical change.<br>• The differences between potential and kinetic energy.<br>• The relationship between chemical reactions of effervescent tablets and variables such as the solvent, temperature of the solvent, and the size of the tablet. |
| **Students will be able to…** | • Plan and conduct well-designed investigations.<br>• Design data tables and charts.<br>• Collect and analyze data.<br>• Graph data.<br>• Draw conclusions from data.<br>• Use evidence to support findings.<br>• Design and test Alka-Seltzer rockets. |

# Overview of 3-2-1 Lift Off - Stage Two of UbD (Assessment Evidence)

**Module Performance Task**

**Summary written in (GRASPS) form - Goal, Role, Audience, Situation, Product and/or Performance, and Standards for Success**

"3-2-1 Lift Off" is a school wide/district wide engineering challenge for upper elementary students. In this challenge students engineer effervescent tablet (Alka-Seltzer) powered rockets.

To compete in the challenge, students learn about Alka-Seltzer rockets by designing and testing (engineering) them. Their rocket design and test data are evaluated using the rubric "Alka-Seltzer Rocket Design" which is located in the TG and SDRB.

The rocket launch is powered by a chemical reaction—Alka-Seltzer in a liquid. In order to participate in the challenge, students must work as a scientist, a mathematician, and an engineer investigating and using this chemical reaction.

**The goal is to engineer—design, build, test, and re-test—a rocket that will achieve the highest launch height using an effervescent tablet (such as Alka-Seltzer) and a liquid.**

**Key Criteria**

Students:

- Identify and controls variables in all investigations of the reactions of Alka-Seltzer and various liquids.
- Plan and conduct well-designed investigations on the amounts of and particle size of the Alka-Seltzer, as well as the temperature of liquids.
- Construct and document the designs of various Alka-Seltzer powered models.
- Construct scientific drawings of teacher demonstrations, their own investigations, and of their model rockets.

**Other Evidence**

Students:

- Construct data tables for investigations.
- Construct graphs for the temperature investigation (Activities 3 and 4).
- Work within cooperative groups.
- Perform satisfactorily on the end-of-module summative assessment (e.g., facts, concepts, and applications of forms of energy, chemical reactions, and well-designed investigations).

## An Overview of 3-2-1 Lift Off - Stage Three of UbD (Learning Plan)

| Backward Mapping from National Standards | | | | |
|---|---|---|---|---|
| National Standard Category | Content Standard | | Content Standard Descriptors (Benchmarks) | Learning Plan |
| National Science Education Standards (1996)<br><br>Science as Inquiry | Standard A: As a result of their activities in grades 5-8 students should develop: | Abilities to do scientific inquiry. | Design and conduct a scientific investigation. | Students will record data throughout Activity 3. Students test their prediction and will have an opportunity to revise a written set of procedures in Activity 3e. Students will read and follow a set of written directions in Activities 3a and 3b. Students should wear goggles during Activities 3a and 3b as evidence of following safety procedures in the lab.<br>In Activity 4a, students must develop a prediction for the investigation. In Activity 4c, students develop a table for recording their data. In Activity 4f, students discuss the components of a well-designed investigation. In Activity 4b students follow written procedures for conducting an investigation and then conduct the investigation using appropriate safety equipment. In Activity 4g, students plot collected data on a graph.<br>In Activity 4h, students develop a conclusion for their investigation. |
| | | Understandings about scientific inquiry. | Think critically and logically to make the relationships between evidence and explanations.<br><br>Communicate scientific procedures and explanations. | |
| National Science Education Standards (1996)<br><br>Physical Science | Standard B: As a result of their activities in grades 5-8 students should develop an understanding of: | Properties and changes of Matter. | Substances react chemically in characteristic ways with other substances to form new substances (compounds) with different characteristic properties. | Activity 1 – Students respond to several questions (1a-1d) designed to probe for an understanding of science processes and physical and chemical changes. Responses will be assessed and discussed using the assessment tools in the Assessment/Evaluation Guide. |
| | | Transfer of energy. | Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways. | Activity 2 - Students will observe and record observations of Alka-Seltzer reacting with water (chemical reaction). Concepts of chemical changes, potential energy, kinetic energy, dependent variables, independent variables, and control variables will be introduced. Preliminary understandings of these concepts will be assessed through several questions. |
| | | Motion and forces. | The motion of an object can be described by its position, direction of motion, and speed. The motion can be measured and represented on a graph. | In Activities 7 and 8, students design/ engineer their rockets, test fire them, record data, redesign them, and provide scientific drawings and descriptions of performance, including which variables contributed most to performance. |

## An Overview of 3-2-1 Lift Off - Stage Three of UbD (Learning Plan)

| Backward Mapping from National Standards | | | | |
|---|---|---|---|---|
| National Standard Category | Content Standard | | Content Standard Descriptors (Benchmarks) | Learning Plan |
| National Science Education Standards (1996)<br><br>Unifying Concepts and Processes | As a result of activities in grades K-12 all students should develop understanding and abilities aligned with the following concepts and processes: | Systems, order, and organization. | A system is an organizational group of related objects or components that form a whole. Systems can consist, for example, of organisms, machines, fundamental particles, galaxies, ideas, numbers, transportation, and education. | Throughout the module 3-2-1 Lift Off, students plan and conduct well-designed investigations and then design, construct, and document various models of Alka-Seltzer rockets; collect data consisting of timed measurements of rockets in flight; and answer open-ended questions that call for explanations and interpretations. All of these activities will provide concrete evidence of student understanding of Unifying Concepts and Processes.<br><br>Activity 6 is devoted to the theme of Form and Function which is the underlying and organizing theme for this module.<br><br>In Activities 9-11, students learn about the force of gravity and its effects upon objects as they conduct several investigations on falling objects. Data are collected, organized, and analyzed, and conclusions are drawn for the collected data. |
| | | Evidence, models, and explanation. | …Models are tentative schemes or structures that correspond to real objects, events, or classes of events, and that have explanatory power. | |
| | | Constancy, change, and measurement. | …Changes in systems can be quantified… | |
| | | Form and function. | Form and function are complementary aspects of objects, organisms, and systems in the natural and designed world. | |

# An Overview of 3-2-1 Lift Off - Stage Three of UbD (Learning Plan)

| Backward Mapping from National Standards | | | | |
|---|---|---|---|---|
| National Standard Category | Content Standard | | | Learning Plan |
| National Council of Teachers of Mathematics Standards - (NCTM, 1989) | Standard 9: Algebra (Grades 5-8) | Understand the concepts of variable, expression and equation. | Complete a function table with a given two-operation rule. | In Activities 3, 4, and 5, students develop an understanding of independent and dependent variables.<br><br>In Activities 9, 10, and 11, students learn about the force of gravity and its effects upon objects. They evaluate equations involving density, volume, cross sectional area of an object, speed, velocity and acceleration. |
| | | Represent situations and number patterns with tables, graphs, verbal rules and equations and explore the interrelationships of these representations. | Describe how a change in one variable in a linear function affects the other variable in a table of values. | In Activities 7 and 8, students describe performances of a rocket including which variables contributed the most to performance. |
| | | Analyze tables and graphs to identify properties and relationships. | Evaluate an algebraic expression or formula. | In Activity 10, students determine density using a formula. |
| | Standard 10: Statistics (Grades 5-8) | Systematically collect, organize and describe data. | Organize and display data to make tables using a variety of categories and sets of data.<br><br>Interpret and compare data in double bar graphs.<br><br>Determine the mean or a given data set or data display.<br><br>Apply the range and measures of central tendency to solve a problem or answer a question. | In Activities 3 and 4, students calculate the arithmetic mean of data collected on the investigation on temperature and dissolving time, using the algebraic formula<br><br>Mean: $\bar{x} = \frac{\sum(\text{times})}{n}$ |

## An Overview of 3-2-1 Lift Off - Stage Three of UbD (Learning Plan)

| Backward Mapping from National Standards | | | | |
|---|---|---|---|---|
| National Standard Category | Content Standard | | Content Standard Descriptors (Benchmarks) | Learning Plan |
| National Council of Teachers of Mathematics Standards - (NCTM, 1989) | Standard 10: Statistics (Grades 5-8) | Construct, read and interpret tables, charts and graphs. | Organize and display data to make single bar graphs using a variety of categories and intervals. | In Activities 3, 4 and 5, students measure temperature, time, particle size, and volumes of liquids to design investigations and collect data. Students design data collection tables, graph data with the appropriate type of graph, and draw conclusions based upon collected data. |
| | | Make inferences and convincing arguments that are based on data analysis. | Organize, display and interpret data in double bar graphs. | In Activities 9, 10, and 11, students learn about the force of gravity and its effects upon objects as they conduct several investigations on falling objects. Data are collected, organized, and analyzed and conclusions are drawn from the collected data. |
| | | Develop an appreciation for statistical methods as powerful means for decision making. | Determine the appropriate type of graph to effectively display data. | In Activities 3, 4 and 5, students measure temperature, time, particle size, and volume of liquids to design investigations and collect data. Students design data collection tables, graph data with the appropriate type of graph, and draw conclusions based upon collected data. |
| | Standard 12: Geometry ( Grades 5-8) | Visualize and represent geometric figures with special attention to developing spatial sense. | Draw geometric figures using a variety of tools. | In Activities 7 and 8, students design/engineer their rockets, test fire them, record data, redesign them, and provide scientific drawings and descriptions of performance, including which variables contributed most to performance. |
| | | Represent and solve problems using geometric models. | Identify, describe or draw a polygon. | While engaged in Activities 7 and 8, students will design and build their rockets based upon concepts of aerodynamics, which involve various geometric shapes. |

## An Overview of 3-2-1 Lift Off - Stage Three of UbD (Learning Plan)

| Backward Mapping from National Standards | | | | |
|---|---|---|---|---|
| National Standard Category | Content Standard | | Content Standard Descriptors (Benchmarks) | Learning Plan |
| National Council of Teachers of Mathematics Standards - (NCTM, 1989) | Standard 13: Measurement (Grades 5-8) | Extend their understanding of the process of measurement. | Determine start, elapsed and end time. | In Activity 1, materials are weighed on a triple beam balance before and after an experience<br><br>In Activities 3, 4 and 5, students measure temperature, time, particle size, and volume of liquids to design investigations and collect data. |
| | | Estimate, make and use measurements to describe and compare phenomena. | Determine equivalent units of measurement. | In Activity 5, students design their own investigations by writing procedures, which include the tools, techniques and measurements for their investigations. |
| | | Select appropriate units and tools to measure to the degree of accuracy required in a particular situation. | Select and use appropriate tools and units. | In Activities 7 and 8, students design/engineer their rockets, test fire them, record data, redesign them and provide scientific drawings and descriptions of performance, including which variables contributed most to performance. |
| | | Extend their understanding of the concepts of perimeter, area, volume, angle measure, capacity, and weight and mass. | Estimate and determine the volume of a cylinder.<br><br>Determine the surface area of geometric solids. | In Activities 3, 4 and 5, students measure temperature, time, particle size, and volume of liquids to design investigations and collect data. |
| | | Develop the concepts of rates and other derived and indirect measurements. | | In Activities 3, 4 and 5, students measure temperature, time, particle size, and volume of liquids to design investigations and collect data. |
| | | Develop formulas and procedures for determining measures to solve problems.<br>. | Measure a single angle and angles in regular polygons. | In Activities 7 and 8, students determine the angle of the launch at its highest point. |

## An Overview of 3-2-1 Lift Off - Stage Three of UbD (Learning Plan)

<table>
<tr><th colspan="4">Backward Mapping from National Standards</th></tr>
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<tr><td>(b) Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.</td></tr>
<tr><td>(d) Process data and report data.</td></tr>
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## An Overview of 3-2-1 Lift Off - Stage Three of UbD (Learning Plan)

| Backward Mapping from National Standards | | | |
|---|---|---|---|
| National Standard Category | Content Standard | Benchmark | Learning Plan |
| Standards for Technological Literacy, Grades 3-5 (ITEA, 2007) | Assess the Impact of Products and Systems | F. Test and evaluate the solutions for the design problem. | Activity 2 - Students will observe and record observations of an Alka-Seltzer reacting with water (chemical reaction). Concepts of chemical changes, potential energy, kinetic energy, dependent variables, independent variables, and control variables will be introduced. Preliminary understandings of these concepts will be assessed through several questions.<br><br>In Activities 7 and 8, students design/ engineer their rockets, test fire them, record data, redesign them, and provide scientific drawings and descriptions of performance, including which variables contributed most to performance. While engaged in Activities 7 and 8, students will design and build their rockets based upon concepts of aerodynamics, which involve various geometric shapes. |
| | | G. Improve the design solutions. | |
| | Use and Maintain Technological Products and Systems | D. Follow step-by-step directions to assemble a product. | |
| | | E. Select and safely use tools, products, and systems for specific tasks. | |
| | | F. Use computers to access and organize information | |
| | Energy and Power Technologies | C. Energy comes in different forms | |
| | | D. Tools, machines, products, and systems use energy in order to do work | |

# General Implementation Hints for Teachers

**Learning Activities (WHERETO)**

The acronym **WHERETO** summarizes the key elements that should be found in the learning plan, given the desired results and assessments in Stages One and Two. Note that the elements need not appear in the same order as the letters of the acronym. Think of **WHERETO** as a checklist for building and evaluating the final learning plan, not a suggested sequence. For example, the learning might start with the Hook (H), followed by instruction on the final performance requirements (W), then perhaps some rethinking of earlier work (R).

| **WHERETO** Elements | |
|---|---|
| W | **WHERE** is this module going and **WHY**?<br>**WHAT** is expected? |
| H | How will we **HOOK** and **HOLD** student interest? |
| E | How will we **EQUIP** students to **EXPLORE** and **EXPERIENCE** the expected performances? |
| R | How will we help students to **RETHINK**, **REHEARSE**, **REVISE**, and **REFINE?** |
| E (E-2) | How will students self-**EVALUATE** and **REFLECT** on their learning? |
| T | How will we **TAILOR** learning to different needs, interests, and learning styles? |
| O | How will we **ORGANIZE** and sequence learning? |

**WHERETO** elements are delineated in each activity.

*Continued on next page*

**Teaching and Assessing Student Progress**

**What is the philosophical, theoretical, and classroom-proven foundation for this UbD designed STEM module? How do I use it for teaching and assessing student progress?**

- This module has been designed using concepts from *Understanding by Design* (Wiggins and McTighe, 1998) and particularly the backward mapping and WHERETO (description of WHERETO appears on page 17) techniques advocated by the authors.
- This module has been back-mapped from the National Science Education Standards (NRC, 1996), National Council of Teachers of Mathematics Standards (NCTM, 1989), National Technology Standards (ISTE, 2007), and the Standards for Technological Literacy, (ITEA, 2007).
- This module has been designed using a **modified 5E** (**E**ngage, **E**xplore, **E**xplain, **E**laborate, and **E**valuate) teaching, learning, and assessing cycle (Trowbridge, Bybee, and Powell, 2000). The 5E teaching, learning, and assessing cycle within this module is not linear in design but is recursive. There will be many Explorations coupled with specific Explanations, with fewer Elaborations; therefore, not every E will necessarily be in every lesson. However, every lesson should contain an Engagement and an Evaluation, with other E's "sandwiched" between.
- A typical one-day lesson follows an "**Engage – Other E's – Evaluate"** format using the activities and assessment/evaluation tools within the module. For closure to each day's lesson, assess (Evaluate) student achievement either through self assessment, peer assessment, or teacher assessment. It is not necessary that the classroom teacher formally assesses and scores each activity.
- Problem-based learning is used to Engage the student in this module and is then revisited in the Module Elaboration.
- Two types of Engagement activities are advocated within this module – a module Engagement (tells the student where the module is headed and what is expected of them) and a Daily Lesson Engagement (relates each lesson to the Module Engagement).
- The module Engagement is developed using **GRASPS** (**G**oal, **R**ole, **A**udience, **S**etting, **P**roduct/**P**erformance, and **S**tandards for evaluating student work).

*Continued on next page*

# General Implementation Hints for Teachers, Continued

**Teaching and Assessing Student Progress** (continued)

- Each module contains many lessons (many Explorations and Explanations) and will vary in length, depending upon student progress and their understanding of science concepts and development of skills and processes.

- Begin each lesson within the module with a Lesson Engagement which would include: review of the work of the previous lesson as it relates to the module engagement, statement of the objective for the lesson (which includes the assessment of the lesson), pre-assessment of student understanding, and any pre-teaching and modeling which students might need to be successful on the lesson to follow. Some lessons will need more teacher direction than others.

- Both formative and summative assessments are an integral part of this module The focus is on collecting evidence, including artifacts and products (Carlson, Humphrey, and Reinhardt, 2003) of student understanding throughout the module so that **assessment can be used to guide instruction.**

- Examine the performance vocabulary to identify the terms students will need to know in order to complete the tasks (e.g., describe, explain, illustrate, analyze, compare, predict, persuade). Teach students how to respond appropriately to these prompts.

- Teach students to determine the number of separate steps required to complete activities and how to keep track of each step as they work through the activity. Use the CUCC strategy as cues for reading and following directions:

| **Circle** | **Underline** | **Count** | **Check** |
|---|---|---|---|
| ◯ | ______ | (1, 2, 3, etc.) | √ |

**Circle** the key direction words.
**Underline** the information that goes with direction word.
**Count** (1, 2, 3 etc.) by numbering each direction word in order to show the number of steps that need to be completed.
**Check** and complete each step that has been numbered.

A master copy of CUCC is included in the TG that may be copied for student use.

- Share with the students prior to, during, and after the activity any non-task specific assessment/evaluation tools (rubrics and checklists) to identify the characteristics of excellent responses. “Paint the target.”

*Continued on next page*

**Teaching and Assessing Student Progress** (continued)

- Use textbooks, audiovisuals, and other expository materials primarily during and after the Explanation phase of each activity. Almost without exception, use these materials only after the Exploration phase.
- Use the modules to illustrate the characteristics of performance assessment tasks (e.g., call for thoughtful applications of knowledge in "authentic" contexts and use established criteria to evaluate student products and performances).
- Use these modules as models for planning and developing new UbD modules.
- Use lower grade-level (easier) modules with students to familiarize them with the requirements of performance-based instruction and assessment. Using lower level modules minimizes the content difficulty and allows students to focus on the process.
- Allow students to use the criteria to select examples ("anchors") of student responses that meet and do not meet the criteria.
- Teach students how to use the assessment/evaluation tools to evaluate and revise their own work. Have them work in groups to give each other feedback (peer response) based upon the identified criteria.
- Periodically, impose a reasonable time limit for the student to respond to task activities. This will give students some preparation for the time constraints of state-mandated summative testing/assessment.

## Student Readiness for Success

**Module Description**

This module is ideally taught at the first part of the school year, as it focuses on STEM knowledge and processes and on "doing" science, technology, engineering, and mathematics. Students investigate the theme of "form and function," learn about science concept of energy, and use the scientific process to experiment with variables that might affect the dissolving time of an effervescent antacid tablet in a chemical reaction. Students conduct three investigations of independent variables that might affect the dissolving time: temperature, particle size, and type of liquid. Students will discover the importance of controlling variables as they experiment. They will identify the independent variable, controlled variables, and dependent variables, then collect and graph data on these variables. Finally, they will use the knowledge they have gained to design, build, and launch (engineer) a rocket powered by an effervescent tablet.

**Common Student Preconceptions**

- Physical changes and chemical changes in matter are the same thing.
- The mass of a material changes before and after a physical change.
- Gravity is selective; it acts differently or not all on some matter.
- Gravity increases with height.
- Gravity requires a medium to act through.
- Heavier objects will fall faster to the earth .than light objects
- There is no gravity in space.
- Rockets in space require a constant force.
- Science is "done" only by white men in lab coats.
- Science is not something that is done by ordinary people.

**Prior Knowledge and Skills**

Students need to have a general understanding of the scientific process and what constitutes a well-designed investigation (information included in this Teacher Guide) to be successful in this module, although many of the relevant ideas related to the scientific process are explained as students work through the module. It may be worthwhile to review the words *prediction*, *procedure*, *variable*, and *conclusion* with students before or during beginning the module as a differentiation instructional strategy. Components of a well-designed investigation can be found in the TG (pages 30-33) that could be copied for students.

Students will need to be able to read temperature from a Celsius thermometer to the nearest degree and to calculate the mean of a set of data. Also, the ability to measure volumetrically with a graduated cylinder will be required.

*Continued on next page*

## Student Readiness for Success, Continued

**Mathematics Readiness**

STEM-CIP modules provide students with many opportunities to use and apply mathematics within the context of STEM. As a result students must possess the necessary and enabling mathematics knowledge and skills needed to perform effectively and achieve desired results. Consequently, an assessment of mathematics knowledge and skills needed will be part of every STEM-CIP module. Teachers should administer the mathematics pre-assessment to check for student understanding. Students will need to know the mathematical concepts within the pre-assessment for successful completion of the activities within the module.

At the end of most activities in a STEM-CIP module is a section called "Check Your Understanding", which consists of selected response items that lend themselves to the use of Student Response Systems for ease of scoring and immediate feedback on student understanding. Mathematics assessment items will appear in this section as well.

**Safety Issues**

Students should be told **not to taste the effervescent tablets or solutions** they use throughout the module.

**Safety goggles should be worn by all students at all times when mixing the Alka-Seltzer and water.**

## Background Information for Teachers

**Intent of Module**

This module deals with the idea of designing and conducting well-designed investigations. In order for an experiment to be considered a controlled test, only one variable at a time (called the independent variable) can be changed. All other variables must be kept the same or controlled. A quick review of the parts of a scientific investigation and the concept of variables are listed below. A master copy can be found in the TG (pages 30-33) for use with students if they are having difficulty with this concept as they work through this module. This section can be easily copied for students who need additional help.

**Websites**

The first five websites listed below are specific to the construction of an Alka-Seltzer rocket.

http://quest.arc.nasa.gov/space/teachers/rockets/act3.html

http://www.alkaseltzer.com/as/experiment/student_experiment.htm

http://www.alka-seltzer.com/asp/student_experiments_8.html

http://www.uidaho.edu/idahotech/lessons/rockets/rocket.html

http://www.gk-12.osu.edu/Lessons/4th%20Grade/Alka%20Seltzer%20Cannons%204.pdf

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- http://mpassero.tripod.com/rocket/seltzer/seltzer.htm - Information about designing and launching paper rockets propelled by Alka-Seltzer and water in an effort to demonstrate Newton's Third Law.
- http://www.grc.nasa.gov/WWW/K-12/airplane/newton1g.html - Excellent background information on Newton's First Law of Motion, which is an integral concept of this module.
- http://www.glenbrook.k12.il.us/gbssci/phys/Class/newtlaws/u2l1a.html - Excellent background information on Newton's First Law of Motion, which is an integral concept of this module.
- http://www/lerc.nasa.gov/WWW/K-12/airplane/newton3.html - Excellent background information on Newton's Third Law of Motion, which is an integral concept of this module.

*Continued on next page*

**Website** (continued)

- http://www.glenbrook.k12.il.us/gbssci/phys/Class/newtlaws/u214a.html
  Excellent source of information on Newton's Laws of Motion

- http://www-istp.gsfc.nasa.gov/stargaze/Sfall.htm - Very useful background information on acceleration due to the force of gravity and provides another explanation of Activity 11 – Rhythms of Gravity.

- http://www.howstuffworks.com/question116.htm - Answers to many questions about the history of Alka-Seltzer, Alka-Seltzer investigations, and Alka-Seltzer rockets.

- http://stanford.edu/~buzzt/gravity.html - Background information on the history of gravity, Sir Isaac Newton, and basic and fun facts about gravity are contained within this site.

- http://csep10.phys.utk.edu/astr161/lect/history/newtongrav.html - What really happened with the apple and Sir Isaac Newton? Also orbital motion, mass and weight, and the gravitational force are discussed at this site.

- http://dbhs.wvusd.k12.ca.us/Matter/2.4bPhysicalChemChanges.html - Background information on physical and chemical changes.

- http://www.mcps.org/bhs/classes/dana/chemphys.html - Physical and chemical properties and changes are addressed at this site. An interactive quiz on these concepts is provided to test understanding.

- http://microgravity.nasa.gov/wimg.html - This is a NASA web site devoted to a discussion of gravity and microgravity.

- http://www.grc.nasa.gov/WWW/K-12/airplane/rktsim.html - This website is an interactive model rocket design and launch simulation where students change the variables (design) of a rocket and simulate its launch.

- http://www.cs.wright.edu/~jslater/SDTCOutreachWebsite/pendulum_esp.htm
  Good background information about pendulum can be found on this website.

*Continued on next page*

**Materials Needed**

The following list is a compilation of materials needed for the entire module. Items are listed per group of students.

**Teacher demonstration in Module Engagement, and Activities 7 and 8**

- 2 fresh effervescent antacid (Alka-Seltzer*) tablets
- Construction paper
- 1 plastic 35-mm film canister** with top (The seal is most important and the lid must seal on the inner portion of the canister for best results.)
- Tape
- Water and eyedropper
- Scissors

* Any brand of effervescent antacid tablets can be used. Generic brand tablets tend to be less expensive.

** Canisters are reusable as long as lids seal properly.

**Activity 1**

- Salt
- Water
- Spoon
- 2 Clear Containers
- Measuring Cup
- Triple beam balance

**Activity 2**

- 1 effervescent antacid tablet (Alka-Seltzer or a generic brand)
- 1 clear container
- Water
- pH indicator

**Activity 3**

- 3 effervescent antacid tablets
- 600 mL Water (200 mL cold, 200 mL room temperature, 200 mL (hot)
- 3 clear cups labeled A, B, C
- Thermometer
- Stopwatch or clock with second hand
- Graduated cylinder or beaker

*Continued on next page*

**Materials Needed** (continued)

**Activity 4**

- 3 effervescent antacid tablets
- Water
- 3 clear cups labeled A, B, C
- Stopwatch or clock with second hand
- Graduated cylinder or beaker
- Plastic knife

**Activity 5**

- Clear plastic cups
- Clear liquid soap
- Paper towels
- White vinegar
- Styrofoam cups
- Salt
- Clock or stopwatch
- Clear oil
- Water
- Seltzer water
- Effervescent tablets
- Beaker or graduated cylinder

**Activity 9**

- Tennis ball
- Baseball
- Ping Pong Ball
- Pencil
- Ruler

**Activity 10**

- Three 8.5 x 11 - inch pieces of paper

**Activity 11**

- Two pieces of string 200 cm each with weights attached
- Hard surface area, such as a cafeteria tray or baking sheet
- Weights (25) – e.g. small binder clips, washers, beads, fishing sinkers, paper clips. Note: although clips are easier to attach, they tend to tangle; beads or sinkers (split shot works well and can be purchased at most stores that sell fishing equipment) are better although they are more difficult to attach.

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**Researchable Questions/ Problems**

Good science and engineering investigations begin with a researchable question or problem statement. This question/problem often asks "what if," "how" or "what effect something will have." The question/problem should be one that can lead to an investigation, which will yield either quantitative or qualitative data. A question/ problem that is well written will often identify the independent (manipulated) variable in the experiment.

**Prediction**

A prediction is an attempted scientific answer to the question being investigated. The prediction provides direction for an investigation, attempts to determine the outcome of the investigation, and suggests a possible reason(s) for this outcome. The prediction should be based on prior knowledge or observations and is proven true or untrue by the investigation.

**Verification**

Materials used in the investigation need to be listed in specific amounts and sizes (e.g., 12 – 100 mL graduated cylinders). This allows other people to replicate (repeat) the experiment exactly to see if they get the same results. This process is called verification.

**Procedure**

The procedure used in an investigation must be written in a clear, logical, and sequential manner in order to allow someone else to follow the same steps to replicate the investigation. In determining the procedure used in the investigation, the factors called variables that will affect the outcome of the experiment must be identified and carefully controlled. Numbered steps in the procedure are helpful.

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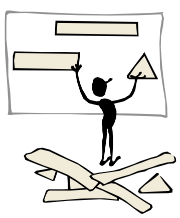
**Types of Variables**

- **Independent (manipulated) variable** - this factor is manipulated (changed) during the investigation in order to find out what effect it has on something else. An example of an independent variable is using different sizes of effervescent tablets in order to observe dissolving time.
- **Dependent (responding) variable** - this factor is observed and measured to see if it is affected by the manipulation of the independent variable. An example of a dependent variable is the dissolving time of effervescent tablets.
- **Variables that are controlled** - these factors in an investigation must be kept constant (controlled - exactly the same) to make sure that they are not having any effect on the dependent variable. Examples of variables that should be controlled in some of the investigations in this module would be the type of effervescent tablets, the type of film canister, the timing device, and the rocket design. However, these could become independent variables depending upon the design of the investigation.

**Results**



The results of the investigation include the measurements taken and observations made, as well as a written explanation of the outcome. Data that are observed or measured during the investigation should be recorded as the investigation is conducted. The best format to collect data is called a data collection table. When constructing a data collection table, it should be remembered that repeated trials of the investigation must be conducted to obtain valid results. Data can then be analyzed and graphed. A statistical analysis of the collected data to include the mean, median, mode, and range can be completed where appropriate. It is helpful to present the data in the form of a graph so that the data illustrated can easily be interpreted. See the following sections for the two most commonly used types of graphs for science investigations.

**Types of Graphs**

**Bar graphs** are used to display discrete data, or data that are distinct and separate from other information. Data shown on a bar graph often reflect measured or counted amounts. For example, the average number of drops of plain water versus the average number of drops of soapy water that will fit on a penny would best be shown on a bar graph. The bars drawn on a bar graph must all be the same width and are separated by spaces in between them.

*Continued on next page*

**Types of Graphs** (continued)

**Line graphs** are used to display continuous data or data that go on without a stop or break. Investigations that have dependent (responding) variables involving temperature, time, or distance, will usually yield data that should be graphed as a line graph. Line graphs are useful to analyze relationships among collected data. In particular, line graphs can show trends in data - increasing, decreasing, or staying the same. The dissolving time of a solid in a range of many different temperatures would be an example of data best displayed on a line graph.

The independent (manipulated) variable is usually represented on the horizontal (x) axis of a graph and the dependent (responding) variable is represented on the vertical (y) axis of a graph. The graph should also have:

- Numbers in even intervals (1's, 2's, 5's, 10's, 100's, etc.)
- Labels for both the horizontal (x) and vertical (y) axes
- A title that reflects the information that is being represented on the graph

**Conclusion**

A conclusion has four parts. It should:

- State whether the prediction was supported or not.
- Answer the original question that started the investigation and include results used as the basis for that conclusion.
- Include inferences that can be made from the results of the investigation.
- Include any additional questions that could be investigated or information that could be researched in the future. In addition, any problems that were experienced during the investigation can be discussed.

**Well-Designed Scientific Investigation**

Conducting a well-designed investigation is a major component of this module Care must be taken to follow experimental procedures. An experiment will be designed to test a prediction. When planning an experiment remember to keep everything the same except for the single variable being used.

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# WELL-DESIGNED INVESTIGATION (master copy)

**Researchable Questions/ Problems**

Good science and engineering investigations begin with a researchable question or problem statement. This question/problem often asks "what if," "how" or "what effect something will have." The question/problem should be one that can lead to an investigation, which will yield either quantitative or qualitative data. A question/ problem that is well written will often identify the independent (manipulated) variable in the experiment.

**Prediction**

A prediction is an attempted scientific answer to the question being investigated. The prediction provides direction for an investigation and attempts to determine the outcome of the investigation and suggests a possible reason(s) for this outcome. The prediction should be based on prior knowledge or observations and is proven true or untrue by the investigation.

**Verification**

Materials used in the investigation need to be listed in specific amounts and sizes (e.g., 12 – 100 mL graduated cylinders). This allows other people to replicate (repeat) the experiment exactly to see if they get the same results. This process is called verification.

**Procedure**

The procedure used in an investigation must be written in a clear, logical, and sequential manner in order to allow someone else to follow the same steps to replicate the investigation. In determining the procedure used in the investigation, the factors, called variables, that will affect the outcome of the experiment must be identified and carefully controlled. Numbered steps in the procedure are helpful.

**Three Types of Variables**

- **Independent (manipulated) variable** - this factor is manipulated (changed) during the investigation in order to find out what effect it has on something else. An example of an independent variable is using different sizes of effervescent tablets in order to observe the effect on dissolving time.

- **Dependent (responding) variable** - this factor is observed and measured to see if it is affected by the manipulation of the independent variable. An example of a dependent variable is the dissolving time of effervescent tablets.

- **Variables that are controlled** - these factors in an investigation must be kept constant (controlled - exactly the same) to make sure that they are not having any effect on the dependent variable. Examples of variables that should be controlled in some of the investigations in this module would be the type of effervescent tablets, the type of film canister, the timing device, and the rocket design. However, these could become independent variables depending upon the design of the investigation.

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**Results**

The results of the investigation include the measurements taken and observations made as well as a written explanation of the outcome. Data that are observed or measured during the investigation should be recorded as the investigation is conducted. The best format to collect data is called a data collection table. When constructing a data collection table, it should be remembered that repeated trials of the investigation must be conducted to obtain valid results. Data can then be analyzed and graphed. A statistical analysis of the collected data to include the mean, median, mode, and range can be completed where appropriate. It is helpful to present the data in the form of a graph so that the data illustrated can easily be interpreted. See the following sections for he two most commonly used types of graphs for science investigations.

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**Bar graphs** are used to display discrete data, or data that are distinct and separate from other information. Data shown on a bar graph often reflect measured or counted amounts. For example, the average number of drops of plain water versus the average number of drops of soapy water that will fit on a penny would best be shown on a bar graph. The bars drawn on a bar graph must all be the same width and are separated by spaces in between them.

**Line graphs** are used to display continuous data, or data that go on without a stop or break. Investigations that have dependent (responding) variables involving temperature, time, or distance will usually yield data that should be graphed as a line graph. Line graphs are useful to analyze relationships among collected data. In particular, line graphs can show trends in data - increasing, decreasing, or staying the same. The dissolving time of a solid in a range of different temperatures would be an example of data best displayed on a line graph.

The independent (manipulated) variable is usually represented on the horizontal (x) axis of a graph and the dependent (responding) variable is represented on the vertical (y) axis of a graph. The graph should also have:

- Numbers in even intervals (1's, 2's, 5's, 10's, 100's, etc.)
- Labels for both the horizontal (x) and vertical (y) axes
- A title that reflects the information that is being represented on the graph

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**Conclusion**

A conclusion has four parts. It should:

- state whether the prediction was supported or not.
- answer the original question that started the investigation and include results used as the basis for that conclusion.
- include inferences that can be made from the results of the investigation.
- include any additional questions that could be investigated or information that could be researched in the future. In addition, any problems that were experienced during the investigation can be discussed.

**Well-Designed Scientific Investigation**

Conducting a well-designed investigation is a major component of this module and care must be taken to follow experimental procedures. Design an experiment to test the prediction. When planning your experiment remember to keep everything the same except for the single variable being used.

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## WELL-DESIGNED INVESTIGATION (master copy) Continued

**Sample Investigation**

| Elements | Description |
|---|---|
| Question | How will the amount of fertilizer used affect the growth of tomato plants? |
| Prediction | If the amount of fertilizer is increased, then there will be greater growth in tomato plants. |
| Independent Variable | Amount of fertilizer used |
| Dependent Variable | Growth of tomato plants |
| Control Variables | • All seeds must all come from the same package.<br>• Al seeds must be planted in the same sized pots with similar soil.<br>• All plants must receive exactly the same amount of water and light.<br>• The temperature should be the same for all test plants.<br>• More than one plant should be used in each test group (i.e., in case one type of seed grows better at this time of year than another).<br>• More than one seed should be placed in each container (i.e., in case one seed is damaged).<br>• Set one group as the CONTROL GROUP. This group is NOT given fertilizer.<br>• Set up two other test groups. One receives a certain amount of fertilizer and the other receives twice as much. |
| Analysis of Data | A line graph showing growth of plants |
| Conclusion | • Was the prediction supported or not?<br>• Which plant group grew the most? Why or why not? What data supports this?<br>• What would you do differently next time?<br>• What new questions arose during the investigation? |

**Master Copy**

# Cues for
# Reading and Understanding

Circle

Underline

Count (1, 2, 3, etc.)

Check √

# Mathematics Readiness Assessment

**Necessary Mathematics Knowledge and Skills**

The use of mathematics knowledge and skills is an integral component of this module. Administering this readiness assessment will help determine if students possess the necessary mathematics background to successfully complete the activities within *3, 2, 1 Lift Off*. Strategies should be developed to assist students if needed.

**Best Graph To Display Data**

**Select and justify the type of graph that would best display data.**

**1.** What is the most appropriate type of graph to best display the favorite ice cream of the students in the fifth grade?
**B. Bar graph**

**2**. What is the most appropriate type of graph to best display the number of home runs hit by Cal Ripken per year over five years?
**A. Line graph**

**3**. Bobby is conducting an experiment to prove that the spinner he and his friends used to play a board game is unfair. He decides to spin the spinner 50 times to find out which color is landed on most often: yellow, green, red or blue. Each time Bobby spins the spinner, he records the outcome on a graph. What type of graph should Bobby create so that he can record data as he is conducting the experiment?
**C. Line Plot**

*Continued on next page*

**Stem and Leaf Plot**

**Construct line plots, line graphs, double bar graphs and stem and leaf plots using whole numbers.**

Use the stem and leaf plot below to answer questions 4 ad 5.

**Hours of TV Watched By Students in Mr. Smith's Class in One Week**

| Stem | Leaf |
|---|---|
| 0 | 3 5 6 6 9 |
| 1 | 0 0 1 4 4 4 8 9 9 |
| 2 | 2 3 4 7 7 7 8 |
| 3 | 1 1 5 |
| 4 | 9 |

Key: 2|3 = 23 hours

**4.** What is the total number of hours of TV watched by the students in Mr. Smith's class?
**D. 482**

**5**. How many students watched more than 18 hours of TV in one week?
**D. 13**

**Central Tendency**

**Calculate, interpret and describe mean, median, mode and range of a set of data.**

Use the following chart to answer questions 6 – 8.

**Hours Spent Listening to Music on One Month**

| **Student** | Tony | Connie | Luke | Yoshi | Francis |
|---|---|---|---|---|---|
| **Hours Per Month** | 72 | 107 | 107 | 86 | 53 |

**6.** What is the mode?
**D. 107**

**7.** What is the mean?
**B. 85**

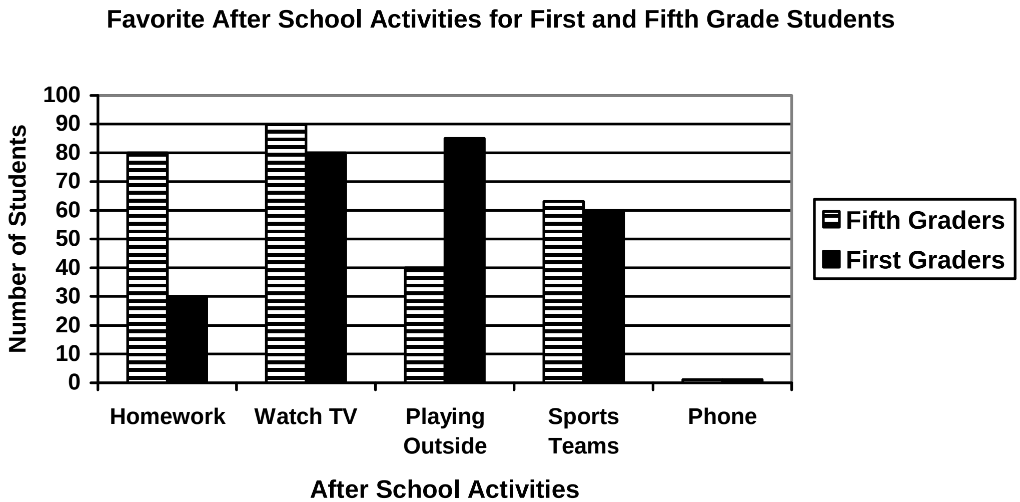
**8.** What is the median?
**C. 86**

*Continued on next page*

**Patterns and Trends**

**Analyze, describe and predict patterns and trends on a graph.**

Use the following graph to answer questions 9 – 11.




**9.** In which after school activity did the first graders have more students?
**C. Playing Outside**

**10.** About how many more fifth grade students than first grade students liked homework?
**B. 50**

**11**. About how many more first grade students than fifth grade students liked playing outside and sports teams?
**D. 45**

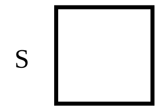
*Continued on next page*

**Perimeter and Area**

**Determine the perimeter of polygons.**
**Determine the area of rectangles and triangles.**

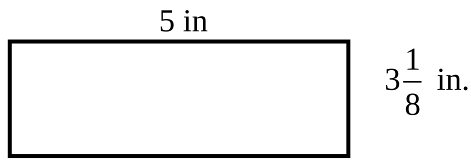
**12.** Which formula would you use to find the perimeter of the square below?

**A. P = 4 x S**



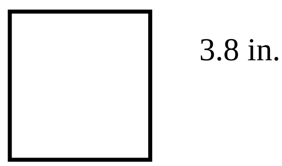

**13.** What is the perimeter of this rectangle?

**C. 16 ¼ in.**



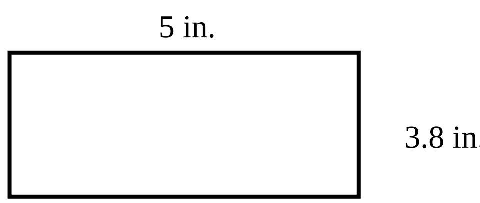

**14.** What is the perimeter of this square?

**D. 15.2 in.**




**15.** What is the area of this rectangle?

**C. 19 in.$^2$**

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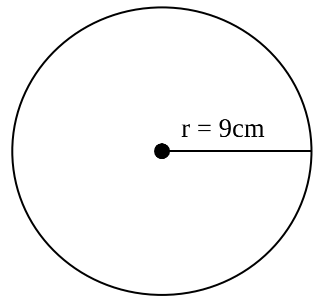
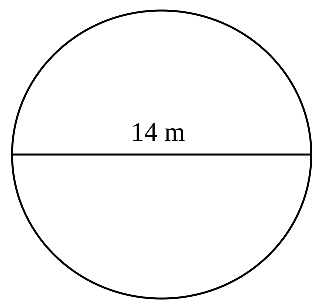
**Circumference and Area of a Circle**

**Use the formula for circumference and area of a circle.**

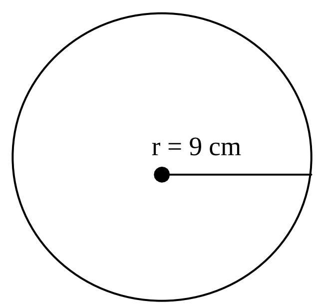
**16**. What is the circumference of the following circle? ( $\pi = 3.14$ )
**D. 56.52 cm**




**17.** What is the circumference of the following circle? ( $\pi = 3.14$ )
**C. 43.96 m**




**18.** What is the area of the following circle? ( $\pi = 3.14$ )
**C. 254.34 $cm^2$**

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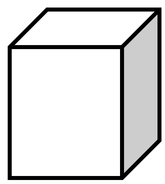
**Volume**

**Calculate the volume from rectangular prisms and use the appropriate unit of measurement.**

**19.** Which unit is NOT a measure of volume?
**A.** $cm^2$

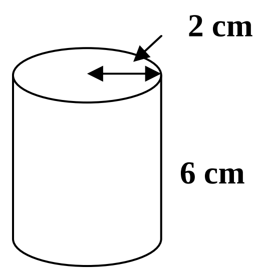
**20.** Which figure is a rectangular prism?
**A.**



**21.** Each side of a cube measures 7 mm. What is the volume of the cube?
**D.** $343\ mm^3$

**22.** A rectangular prism measures 2 m wide, 3 m high and 18 m long. What is its volume?
**D.** $192\ m^3$

**23.** What is the volume of the cylinder to the nearest tenth? Use $\pi = 3.14$
**C.** $75.4\ cm^3$

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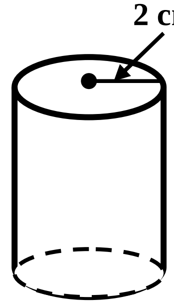
**Surface Area**

**Calculate the total surface area for a rectangular prism and cylinder.**

**24.** What is the total surface area of a rectangular prism that measures 3 feet by 4 feet by 6 feet?
**D. 108 ft$^2$**

**25.** What is the total surface area of a cube that measures 8 meters on each side?
**C. 384 m$^2$**

**26.** What is the total surface area of the cylinder to the nearest tenth? Use $\pi = 3.14$.
**C. 100.48 cm$^2$**

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**Elapsed Time**

**Determine elapsed time to the nearest minute**

Use the following train schedule to answer questions 27 – 29.

| **Train Schedule** | | |
|---|---|---|
| **Arrives** | **Departs** | **City** |
| 7:40 pm | 7:50 pm | Toledo, OH |
| 11:07 pm | 11:15 pm | Cleveland, OH |
| 3:25 am | 3:35 am | Buffalo, NY |
| 9:05 am | 9:35 am | Albany, NY |

**27.** Use the following train schedule to determine how long a train must travel to get from Toledo to Cleveland?
**B. 3 hrs 17 min**

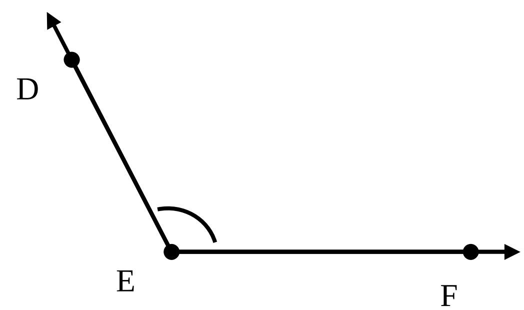
**28.** Which conversion is correct?
**D. 2 ½ hrs = 150 min**

**29**. What is the elapsed time from 3:35 am to 9:05 am
**A**. **5 hrs 30 min**

**Angles**

**Estimate, measure and draw angles to the nearest degree using a protractor.**

**30.** What is the measure of $\angle DEF$?
**A. 115$^o$**

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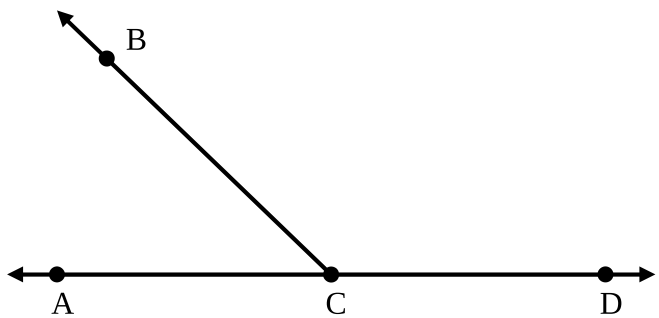
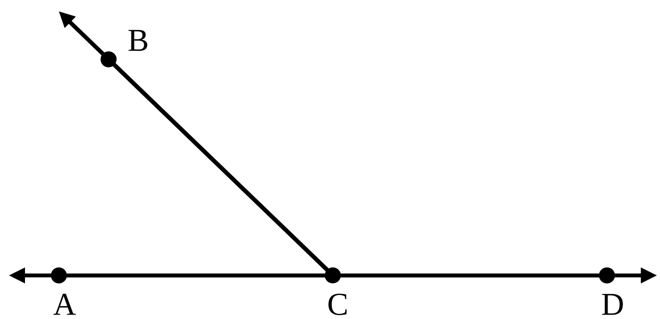
**Angles**
(continued)

**31.** What is the measure of $\angle BCD$?
**D. 135º**




32**.** What is the measure of $\angle ACB$?
**A. 45º**




**Algebraic Expressions**

**Evaluate formulas and algebraic expressions given the value of the variables.**

**33.** What is the value of the expression x + 32, when x = 18?
**D. 50**

**34.** What is the value of the expression 2L + 2W when L = 16 and W = 12?
**C. 56**

**35.** A car traveled at 35 mph for 3 ½ hours. What is the distance the car traveled? Use the formula $d = r \cdot t$. Round your answer.
**D. 123 miles**

*Continued on next page*

**Patterns and Functions**

**Solve problems involving patterns and functions using a calculator when appropriate.**

**36.** What are the values for "x" and "y"?

| Hours Worked (h) | 1 | 2 | 3 | 4 | 80 | y |
|---|---|---|---|---|---|---|
| Toys Produced (p) | 4 | 8 | 12 | 16 | x | 400 |

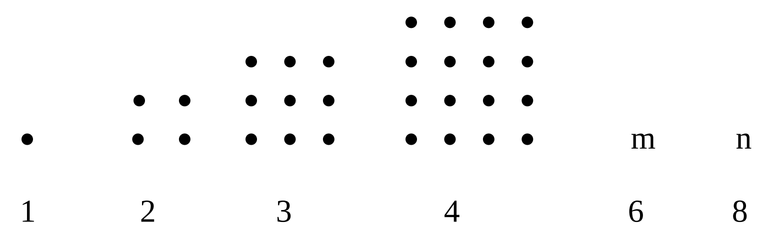
**D. x = 320 y = 100**

**37.** What are the values for "a" and "b"?

| Days (d) | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Total Spiders (t) | 14 | 28 | 56 | 112 | 224 | a | b |

**D. a = 448 b = 896**

**38.** How many dots are needed for drawing m and n?




**C. m = 36 n = 64**

*Continued on next page*

**Functional Relationships**

**Given a functional relationship, describe how a change in one variable results in a change in the other.**

**39.** Which answer describes how a change in “x” results in a change in “y”?

| | | | | | |
|---|---|---|---|---|---|
| x | 2 | 4 | 6 | 8 | 10 |
| y | 10 | 20 | 30 | 40 | 50 |

**A. as “x” increases by 2, “y” increases by 10**

**40.** Which answer describes how a change in “a” results in a change in “y”?

| | | | | | |
|---|---|---|---|---|---|
| a | 5 | 10 | 15 | 20 | 25 |
| y | 11 | 21 | 31 | 41 | 51 |

**C. as “a” increases by 5, “y” increases by ten**

**41.** Which answer describes how a change in “b” results in a change in “t”?

| | | | | | |
|---|---|---|---|---|---|
| b | 64 | 32 | 16 | 8 | 4 |
| y | 4 | 8 | 12 | 16 | 20 |

**A. as “b” is multiplied by 1/2, “t” is increased by 4**

**Evaluation**

Do not formally assess this assessment. Use student feedback to determine a strategy for remediation where necessary.

## Module Engagement: Let's Soar

**Activity Description**

In this section of the module, students watch a teacher demonstration of launching an effervescent tablet rocket. The intent is to get students hooked and excited about effervescent tablet rocketry and elicit preconceptions about how the rocket is propelled.

In this module, students study the science of how an effervescent tablet rocket is launched. They will assume the roles of scientists, mathematicians, and engineers investigating Alka-Seltzer powered rockets and use their findings from several investigations to build and test (engineer) a rocket that will achieve the highest launch height.

The task turns into a contest (engineering challenge) when students compete against other groups in the class and possible groups in other classes.

**WHERETO Elements**

**W** – WHERE is this module going and WHY? WHAT is expected?
**H** – How will we HOOK and HOLD student interest?

**Materials Needed**

- 2 fresh effervescent antacid (Alka-Seltzer*) tablets
- Construction paper
- 1 plastic 35-mm film canisters** with tops (the seal is most important and the lid must seal on the inner portion of the canister for best results.
- Tape
- Water and eyedropper
- Scissors

* Any brand of effervescent antacid tablets can be used. Generic brand tablets tend to be less expensive.
** Canisters are reusable as long as lids seal properly.

**Explanation**

**E1 and E2**. Ask students to <u>draw and label</u> in their SDRB what they observed when the Alka-Seltzer rocket was launched. Below are the parts of a scientific drawing that should be included in their drawings. These criteria should be shared with the students in advance.

- a title
- as many details as possible (e.g., color, shapes, measurements)
- all parts labeled
- a written explanation of what the drawing is intended to show
- an appropriate size for details to be easily recognized

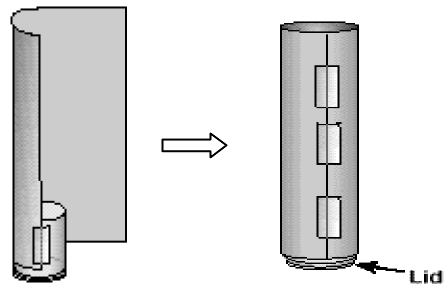
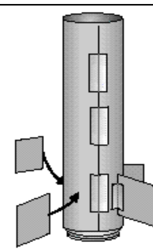
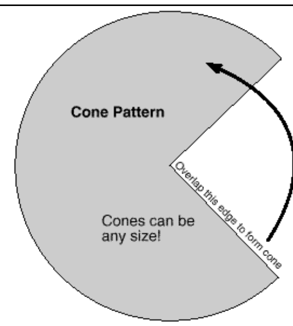
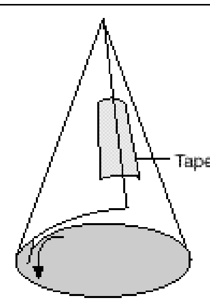
Ask students to describe why the Alka-Seltzer rocket reacted the way it did. Ask them to use words they already know.

*Continued on next page*

**Rocket Construction**

One example of rocket construction can be found on the following website:
[http://quest.arc.nasa.gov/space/teachers/rockets/act3ws1.html](http://quest.arc.nasa.gov/space/teachers/rockets/act3ws1.html)

**However, students should either modify this design or design a new rocket as they engineer their own rockets in Activities 7 and 8.**

| | |
|---|---|
| **Step 1:** Wrap and tape a tube of card stock paper (it comes in different colors) around the film canister. <u>The lid end of the canister goes down!</u> |  |
| **Step 2:** Tape fins to the rocket |  |
| **Step 3:** Cut a cone pattern for the top of the rocket. |  |
| **Step 4:** Overlap and tape. |  |

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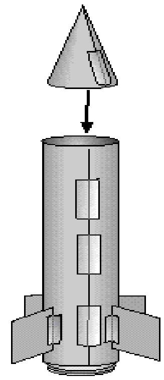
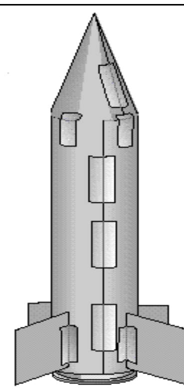
**Rocket Construction (continued)**

| | |
|---|---|
| **Step 5:** Tape the cone to the top of the rocket. |  |
| **Step 6:** Ready for launch. |  |

**Step 7:** Drop 15 – 20 drops of water into the film canister.

**Step 8:** Break the effervescent tablet in half. Drop ½ of a tablet into the canister. Put the top on immediately and flip it upside down so the lid end of the canister is in contact with the tablet.

**Step 9:** In a couple of seconds, the rocket will be launched into the air blowing off the lid with a loud pop.

**Important Notes:**

- Amount of time for the tablet to react with the water will vary. **Run at least 2 -3 trials before doing this as a demonstration for students.**
- This demonstration can be done in the classroom; however, the rocket will probably hit the ceiling.

*Continued on next page*

**Pre-conceptions Assessment**

A brief pre-conceptions assessment is included to measure students' prior knowledge and/or understandings of concepts within the module. The assessment items and answers are below.

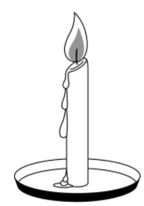
1. What is the name given to the form of energy when a rocket is launched and in motion?
   **A. Kinetic Energy**

2. What is the force that brings a rocket down to Earth?
   **A. Gravity**

3. The four objects listed below are resting on a table top four feet above the floor. Which one of the objects has the greatest potential energy?
   **D. Bowling ball**

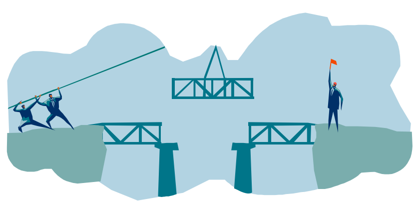
4. Jane stands motionless on her skateboard. Timmy decides to give the skateboard a push. Which of Newton's Laws is best demonstrated by Timmy's push on the motionless skateboard?
   **A. An object at rest will stay at rest until acted upon by a force.**

5. As a candle burns, you observe both chemical and physical changes taking place. Which statement best describes evidence for a physical change?
   **D. The flame causes the wax to melt.**



6. In a scientific investigation, the procedure is
   **A. a step-by-step plan for the investigation.**

7. Which picture below best shows engineering?
   **D.**



8. STEM is an acronym (abbreviation) for
   **D. Science, Technology, Engineering, and Mathematics**

**Evaluation**

Do not formally assess these items, but do discuss results with students.

# Activity 3:  Temperature and Dissolving Time

**Activity Description**

In this structured inquiry activity, students test the effects of temperature on the dissolving time of effervescent antacid tablets. Students first predict the outcome of the investigation, follow a set of written procedures to conduct the temperature investigation, conduct the investigation and finally organize their data into data tables. They then graph their data, compare class data (repeated trials), and then write their conclusion regarding the question. “Does changing the temperature of the water have an effect on the dissolving time of the effervescent antacid tablet?”

**WHERETO Elements**

**E –** How will we EQUIP students to EXPLORE and EXPERIENCE the expected performances?
**R –** How will we help students to RETHINK, REHEARSE, REVISE, and REFINE?

**Materials Needed**

- 3 effervescent antacid tablets
- 600 mL Water (200 mL cold, 200 mL room temperature, 200 mL, hot)
- 3 clear cups labeled A, B, C
- Thermometer
- Stopwatch or clock with second hand
- Graduated cylinder or beaker

**Background Information**

In this activity, students will be testing the effects of temperature on the total dissolving time of effervescent antacid tablets. The materials needed for each group of students are listed in the materials section and the procedures can be found in the SCM. A quick review of how to read the temperature of the water to the nearest degree may be necessary before students begin the hands-on portion of the investigation. Greater water temperature differences will yield better student results. The hot water will significantly speed up the dissolving time of the tablet.

| Variable | Description |
|---|---|
| Independent | Temperature of water |
| Dependent | Total time it takes for tablet to dissolve |
| Controlled | Volume of water, tablet size, type, and amount |

*Continued on next page*

# Activity 3: Temperature and Dissolving Time, Continued

**Background Information** (continued)

Bar graphs are used to show discrete data (i.e., counting data- in this case total dissolving time). In this exploration, it is difficult to measure dissolving of the tablet over a period of time, so the total time is used. If students are not familiar with a bar graph or need a review, help them set up the graph. It is customary for the independent variable to be represented on the X-axis (water temperature). The Y-axis should be the dependent variable (tablet dissolving time). Student may need to convert total dissolving times over one minute to seconds for purposes of graphing. Demonstrating how to create a bar graph from one group's data on the overhead would be helpful before each group constructs their own graph.

In order to collect the class data in 3g, create a data collection chart on the board or overhead. Have each group report their results. In activity 3h, read the criteria aloud for a conclusion. Allow volunteers to share their conclusions. Use the language arts strategy of Praise, Question, and Polish to peer review conclusions. You may also want to listen to the conclusions of several different students, and then create a class conclusion on the overhead.

**Exploration and Evaluation**

**3a**. Prediction: If the temperature of the water is ___ then the dissolving time of the tablet will ______________________ because _______________.

Assessment Rubric

2 = The prediction states a possible outcome of the experiment with a logical reason for the outcome chosen.

1 = The prediction states a possible outcome of the experiment but lacks a logical reason for the outcome chosen.

0 = All other responses.

**3b.**

| **Dissolving Time of Table in Different Water Temperatures** | | | |
|---|---|---|---|
| Cup | Description of Water Temperature | Temperature of Water ( $^{0}$C) | Dissolving Time (seconds) |
| A | Cold | | |
| B | Room Temperature | | |
| C | Hot | | |

Assessment Rubric

2 = Data table is complete with data recorded and all measurements are labeled with an appropriate units (e.g., degrees or seconds).

1 = Data table is complete with data recorded, but data are not labeled with appropriate units of measurements (e.g., degrees or seconds).

0 = Data table is incomplete.

*Continued on next page*

**Evaluation**(continued)

**3c.** What was the independent variable (variable you changed on purpose) in this investigation? What was the dependent variable (i.e., The effect that was measured or counted.)?

*The independent variable is the temperature of the water. The dependent variable is the total dissolving time of the tablet.*

Assessment Rubric

2 = Both the independent and dependent variable are correctly identified.
1 = Either the independent or the dependent variable is correctly identified.
0 = Neither the independent nor the dependent variable is correctly identified.

**3d.** Which variables were controlled (kept the same) in this experiment?

*The controlled variables are the volume of water and the size, type and number of tablets used.*

Assessment Rubric

2 = The response identifies two or more controlled variables.
1 = The response identifies at least one controlled variable.
0 = The response identifies no controlled variables.

**3e.** Was this a well-designed investigation? Why or why not? How would you rewrite the procedures to make this a well-designed investigation? Look back at Activity 1 to see what makes an experiment "well-designed" to help answer this question if necessary.

*A well-designed investigation follows the scientific process, involves controlling variables, and uses repeated trials for data collection.*

Assessment Rubric

2 = The response identifies the investigation as being well-designed or not with supporting reasons.
1 = The response identifies the investigation as being well-designed or not but lacks supporting reasons.
0 = All other responses.

*Continued on next page*

**Evaluation** (continued)

**3f.** A bar graph is used to show counting data – in this case total time. Bar graphs show comparisons of data. Create a **bar graph** that shows how the total time it took for the tablet to dissolve changed as the temperature of the water changed. Be sure to:

- include a title that tells what is being displayed on the graph.
- number the y axes in even intervals (by 1's, 2's, 5's, 10's, 20's, etc.).
- label the x and y axes.
- plot the data from the data table carefully.

Use the performance list for "Graphing Scientific Data" on page 84 of this guide.

**3g.** Calculate the mean (average) dissolving time for each temperature (cold, room temperature, and hot) for all the groups in your class in the chart below.

| **CLASS DATA FOR DISSOLVING TIMES BASED UPON TEMPERATURE** | | | |
|---|---|---|---|
| GROUP NUMBER | TIME (seconds) | | |
| | COLD | ROOM TEMPERATURE | HOT |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| **MEAN** M=∑times/ number of groups | | | |

Now that you have calculated the class means for cold, room temperature and hot water, graph these data on the graph you created in 3f. Compare your group's results to the class results.

*Continued on next page*

**Evaluation**
(continued)

**3h.** Write a conclusion for this investigation. Remember to refer back to your question, prediction, data, charts, and graph as you summarize what you found out. Be sure to include the following:

- whether your prediction was supported or not.
- an answer to the original question.
- a reference to data collected in the investigation.
- additional things you might want to study.

Assessment Rubric

3 = The conclusion is clear and complete and includes - a statement of whether the prediction was supported or not, an answer to the question that began the investigation with supporting data, and additional things that could be tested about dissolving time.

2 = The conclusion is essentially complete but one of the elements of a conclusion (listed above) needs improvement.

1 = The conclusion is not complete - one or more of the elements of a conclusion (listed above) has been omitted.

**Check Your Understanding**

**1.** Based upon the investigation "Temperature and Dissolving Time," you can conclude that as the temperature increases

**B. the Alka-Seltzer dissolves faster.**

**2.** Why did you use class data in "Temperature and Dissolving Time," to compare your results? You can

**C. review your data for consistency with others.**

**3.** In an investigation, the thing that changes is known as the

**D. independent variable.**

**4.** Identifying the question, forming a prediction, and researching are steps in a

**D. scientific investigation.**

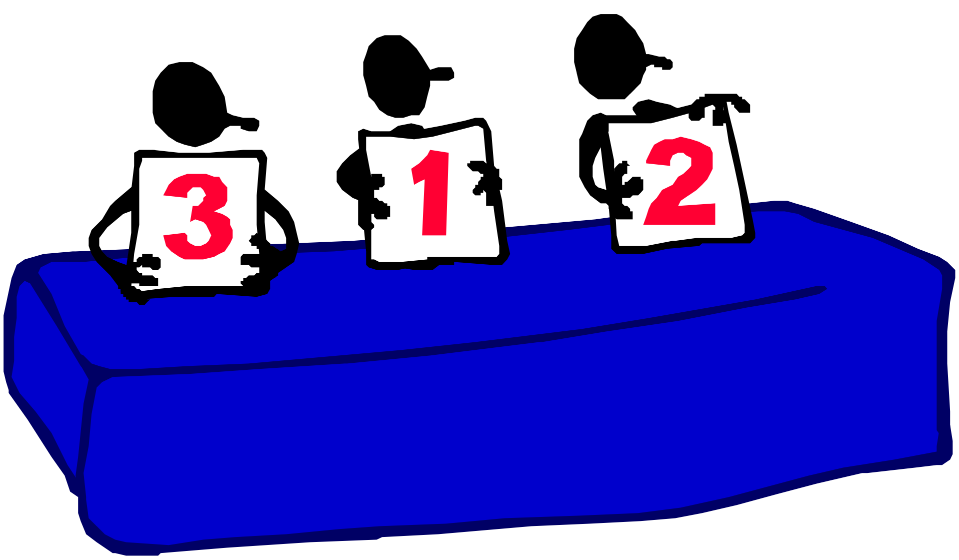
**5.** Why are data tables used in scientific investigations?

**A. Organize the data gathered in an investigation.**

# 3-2-1 Lift Off

## Assessment/Evaluation

## Holistic and Performance List Rubrics



# Alka-Seltzer Rocket Design Rubric

Name ______________________________ Date ___________________ Course/Class______________

Task/Assignment ______________________________________

| Performance Criteria | Points | Self | Teacher | Other(s) |
|---|---|---|---|---|
| 1. I have successfully completed all investigations and questions within the module 3-2-1 Lift Off. | | | | |
| 2. I have worked cooperatively with my team member(s) while completing all investigations within this module. | | | | |
| 3. I have controlled variables in designing and launching my rocket | | | | |
| 4. I have clearly identified both the independent and dependent variables in my final rocket design. | | | | |
| 5. Based upon the knowledge I gained during this module, I have engineered the best rocket I can. | | | | |
| 6 I have followed all the safety rules and guidelines for launching my rockets in my school. | | | | |

(Points, Self, Teacher and Other(s) are under the heading "Assessment".)

O Comments O Goals O Actions

## **Scientific Drawing** (Lantz, 2004)

Name ______________________________Date_______________ Course/Class______________

Task/Assignment_______________________________________

| Performance Criteria | Assessment | | | |
|---|---|---|---|---|
| | **Points** | **Self** | **Teacher** | **Other(s)** |
| 1. My scientific drawing looks similar to what I observed. | | | | |
| 2. I included as many details as possible: colors, textures, shapes, measurements, etc. | | | | |
| 3. I labeled all the parts of my scientific drawing. | | | | |
| 4. I wrote a title that tells what my scientific drawing shows. | | | | |
| 5. I provided a written explanation of what my scientific drawing is intended to show. | | | | |
| 6 My scientific drawing is of an appropriate size for details to be easily recognized. | | | | |

| O Comments | O Goals | O Actions |
|---|---|---|
| | | |

## Graphing Scientific Data **(Lantz, 2004)**

Name ______________________________ Date______________ Course/Class ___________

Task/Assignment ______________________________________

| Performance Criteria | Assessment | | | |
|---|---|---|---|---|
| | Points | Self | Teacher | Other(s) |
| 1. I used an appropriate type of graph (**bar graph, pictograph, stem-and-leaf, circle graph, line plot graph, etc**.) | | | | |
| 2. The title of my graph clearly relates to the information displayed on the graph. | | | | |
| 3. I used my data to choose an appropriate interval to number my x axis and y axis (2's, 3's, 5's, 10's, 100's, etc. | | | | |
| 4. When placing the numbers on my graph, I spaced them evenly. | | | | |
| 5. I labeled all the parts of my graph (modules of measurement, x and y axis, columns, rows, etc.) | | | | |
| 6. My set of data is plotted on the graph accurately. | | | | |
| 7. My graph is clear and complete. | | | | |

O Comments O Goals O Actions

## **Brief Constructed Response to Open-ended Science Questions** (Lantz, 2004)

Name ____________________________ Date _______________ Course/Class _____________

Task/Assignment _________________________________________________

| | |
|---|---|
| **Expert**<br>**4** | The responses show an in-depth understanding of the topic. Relationships among science facts and concepts are clearly, completely, and accurately explained and fully supported with relevant data, examples, or citations. Ideas are expressed clearly and succinctly in a logical manner. All aspects of the questions are addressed. Spelling and language conventions are correctly applied. Language used in the responses is appropriate for the needs of the audience. |
| **Proficient**<br>**3** | The responses show a solid understanding of the topic Relationships among science facts and concepts are explained and generally supported with relevant data, examples, or citations. Ideas are expressed, for the most part, clearly and succinctly. The various aspects of the questions are generally addressed. Spelling and language conventions are generally correct. Language used in the responses is largely appropriate for the needs of the audience. Minor errors do not interfere with meaning. |
| **Emergent**<br>**2** | The responses show a partial understanding of the topic. There is an attempt to explain the relationships among science facts and concepts, but some serious omissions or misconceptions are evident. Insufficient support is provided. Ideas are not always expressed in a clear and logical manner, making the response difficult to follow. The questions are only partially addressed. Flaws in spelling and language conventions interfere. Language used in the response is mostly inappropriate for the needs of the audience. |
| **Novice**<br>**1** | The responses show a very limited understanding of (or serious misconceptions about) the topic. Relationships among science facts and concepts are not explained. Little or no support is provided. Ideas are not presented in a clear and logical manner. The questions are not completely or satisfactorily addressed. Major flaws in spelling and language conventions make the responses difficult to follow. Language used in the responses is inappropriate for the needs of the audience. |

| | | |
|---|---|---|
| O Comments | O Goals | O Actions |

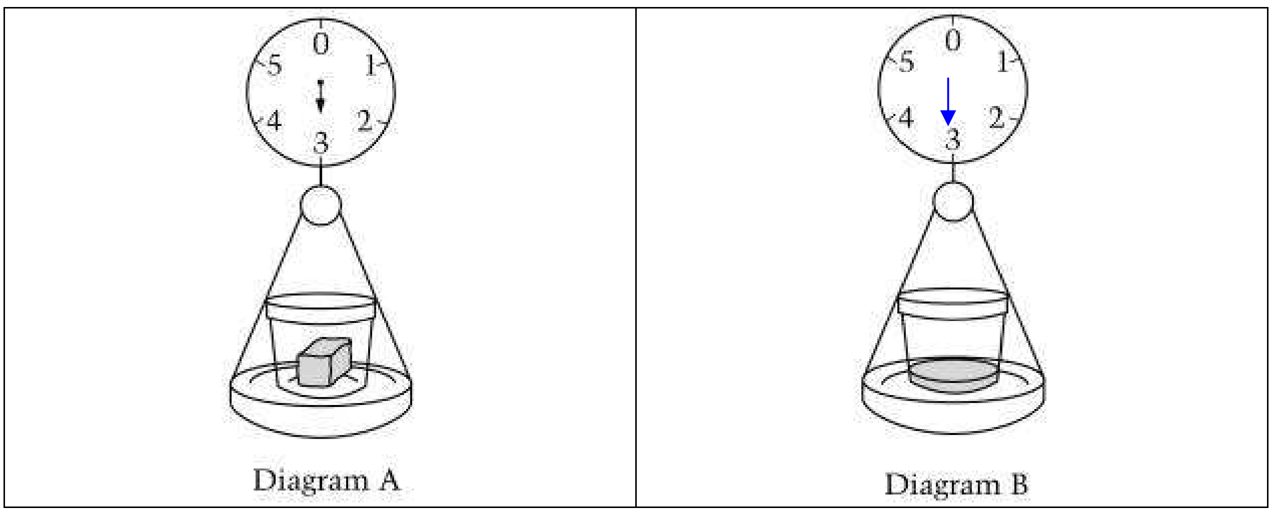
# 3-2-1 Lift Off Module Test with Answers

**1.** Which one of the following is an example of a chemical change?
**D. Wood burning**

**2.** Tearing a piece of paper is an example of
**A. a physical change**

Directions: Read the paragraph below and examine the diagram of Melting Ice. Then answer numbers 3 and 4.

**3.** Tara put an ice cube in a jar, put the lid on the jar, then placed the jar on a scale. The jar and the ice cube weighed 3 units as shown in Diagram A below. Tara came back one hour later and the ice cube had melted. Draw an arrow on Diagram B below to show the weight of the jar and melted ice cube.




**Melting Ice**

**4.** In the experiment above, the weight in Diagram B is an example of
**B. a dependent variable**

**5.** Pat has two kinds of plant food, "Quickgrow" and "Supergrow." What would be the best way for Pat to find out which plant food helps a particular type of houseplant grow the most**?**
**D. Put some Quickgrow on a few plants, put the same amount of Supergrow on a few other plants of the same type, put all the plants in the same place, and see which group of plants grows the most.**

**6.** As an object falls freely, the kinetic energy of the object
**B. increases**

**7.** An object weighing 500 grams is moved from the floor and placed on a shelf. Doing this has

**D. increased its potential energy.**

**8.** A student took three ice cubes from the freezer and put them in a glass of freshly squeezed orange juice. After 10 minutes, the student tried to take the ice cubes out of the juice. There was no ice left. What type of change took place?

**B. physical, because the ice cubes changed into liquid**

**9.** Based upon your work in 3-2-1 Lift Off which definition below best describes engineering? Engineering is

**D. the application of science and mathematics to the needs of humanity.**

**10.** In the space below, describe how you used STEM in the module 3-2-1 Lift Off. Be specific and use examples from your work.

**To score this item, refer to the "Brief Constructed Response to Open-Ended Questions" rubric on page 84 of this guide.**

# References


Educator in Connecticut's Pomperaug Regional School District 15 (1996). Performance-based learning and assessment. ASCD, Alexandria, VA.

International Society for Technology in Education – ISTE (1998, 2007). *National education technology standards for students.* ISTE. Washington, DC.

International Technology Education Association - (ITEA, 2007). *Standards for technological literacy.* Reston, VA.

Lantz, H (2004). *Rubrics for assessing student achievement in science grades K-12.* Thousand Oaks, CA. Corwin Press.

Marzano, Pickering, and McTighe (1993), *Assessing student outcomes: performance assessment using the dimensions of learning model.* ASCD, Alexandria, VA.

McTighe, J. (1999). *Developing performance tasks: tools and templates for designers.* Columbia, MD. Maryland Assessment Consortium.

National Council of Teachers of Mathematics (1989). *Principles and standards for school mathematics.* NCTM. Reston, VA

National Research Council (1996). *National science education standards.* Washington, DC: National Academy Press.

Project 2061, American Association for the Advancement of Science (1993). *Benchmarks for science literacy.* New York: Oxford University Press.

Reeves, D. (2003). *Making standards work: how to implement standards-based assessments in the classroom, school, and district.* Advanced Learning Press, Englewood, CO.

Schlecthty, Phillip (2001). *Shaking up the school house.* San Francisco, CA. Jossey-Bass – A Wiley Company.

Treagust, D., Jacobowitz, R., Gallagher, J., and Parker, J. (2003*). Embed assessment in your teaching.* Arlington, VA. National Science Teachers Association.

Trowbridge, L.W.; Bybee, R.W. and Powell, J.C. 2000.*Teaching Secondary School Science*, Chapter 15, "Models for Effective Science Teaching," Merrill/Prentice Hall, Upper Saddle River, NJ.

Wiggins, G. and McTighe, J. (1998). *Understanding by design*. Alexandria, VA: Association for Supervision and Curriculum Development.

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