

# Unit 01: Motion and Forces

Content Area: **Template**  
Course(s):  
Time Period: **Full Year**  
Length: **FY**  
Status: **Published**

## Standards Alignment

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### New Jersey Student Learning Standards

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#### **Practice 1. Asking questions (for science) and defining problems (for engineering)**

**Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.**

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.

Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

#### **Practice 2. Developing and using models**

**Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.**

Design a test of a model to ascertain its reliability.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

#### **Practice 3. Planning and carrying out investigations**

**Planning and carrying out investigations in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.**

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence

as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems.

Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

#### **Practice 5. Using mathematics and computational thinking**

**Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.**

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

#### **Practice 6. Constructing explanations (for science) and designing solutions (for engineering)**

**Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.**

Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

#### **Practice 8. Obtaining, evaluating, and communicating information**

**Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.**

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.

#### **Connections to the Nature of Science: Most Closely Associated with Practices** **Scientific Investigations Use a Variety of Methods**

Science investigations use diverse methods and do not always use the same set of procedures to obtain data.

Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.

Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge.

#### **Scientific Knowledge is Based on Empirical Evidence**

Science knowledge is based on empirical evidence.

Science disciplines share common rules of evidence used to evaluate explanations about natural systems.

Science includes the process of coordinating patterns of evidence with current theory.

Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

## **PS2: Motion and Stability: Forces and Interactions**

### **PS2.A: Forces and Motion**

Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1)

### **PS2.B: Types of Interactions**

Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.(HS-PS2-4)

## **HS-PS2 Motion and Stability: Forces and Interactions**

### **Students who demonstrate understanding can:**

HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

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| SCI.3.PS2.B   | Types of Interactions   |
| SCI.HS-PS2-1  | Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. |
| SCI.HS-PS2-4  | Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.                     |
| 3-PS2         | Motion and Stability: Forces and Interactions   |
| 3-PS2-2.PS2.A | Forces and Motion   |

## **Integration of Career Readiness, Life Literacies and Key Skills**

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| CRP.K-12.CRP1  | Act as a responsible and contributing citizen and employee.                        |
| CRP.K-12.CRP2  | Apply appropriate academic and technical skills.                                   |
| CRP.K-12.CRP3  | Attend to personal health and financial well-being.                                |
| CRP.K-12.CRP4  | Communicate clearly and effectively and with reason.                               |
| CRP.K-12.CRP5  | Consider the environmental, social and economic impacts of decisions.              |
| CRP.K-12.CRP6  | Demonstrate creativity and innovation.   |
| CRP.K-12.CRP7  | Employ valid and reliable research strategies.                                     |
| CRP.K-12.CRP8  | Utilize critical thinking to make sense of problems and persevere in solving them. |
| CRP.K-12.CRP9  | Model integrity, ethical leadership and effective management.                      |
| CRP.K-12.CRP10 | Plan education and career paths aligned to personal goals.                         |
| CRP.K-12.CRP11 | Use technology to enhance productivity.  |
| CRP.K-12.CRP12 | Work productively in teams while using cultural global competence.                 |

## **Technology / Integration of Computer Science and Design Thinking**

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| TECH.8.1.12     | Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge. |
| TECH.8.1.12.A   | Technology Operations and Concepts: Students demonstrate a sound understanding of technology concepts, systems and operations.   |
| TECH.8.1.12.A.3 | Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue.  |
| TECH.8.1.12.A.4 | Construct a spreadsheet workbook with multiple worksheets, rename tabs to reflect the data on the worksheet, and use mathematical or logical functions, charts and data from all worksheets to convey the results.   |
| TECH.8.1.12.D   | Digital Citizenship: Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior.   |
| TECH.8.1.12.D.1 | Demonstrate appropriate application of copyright, fair use and/or Creative Commons to an original work.  |
| TECH.8.1.12.D.2 | Evaluate consequences of unauthorized electronic access (e.g., hacking) and disclosure, and on dissemination of personal information.  |
| TECH.8.1.12.E   | Research and Information Fluency: Students apply digital tools to gather, evaluate, and use information.   |
| TECH.8.1.12.E.1 | Produce a position statement about a real world problem by developing a systematic plan of investigation with peers and experts synthesizing information from multiple sources.                                      |

## **Interdisciplinary Connections: NJSLs for ELA, Social Studies, Science and/or Math Section**

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| LA.K-12.NJLSA.R  | Reading<br>Key Ideas and Details   |
| LA.RL.11-12.1    | Cite strong and thorough textual evidence and make relevant connections to support analysis of what the text says explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain. |
| LA.K-12.NJLSA.R1 | Read closely to determine what the text says explicitly and to make logical inferences and relevant connections from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.           |
| LA.K-12.NJLSA.R2 | Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.   |
| LA.K-12.NJLSA.R3 | Analyze how and why individuals, events, and ideas develop and interact over the course of a text.<br>Craft and Structure  |
| LA.K-12.NJLSA.R4 | Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.<br>Integration of Knowledge and Ideas      |
| LA.K-12.NJLSA.R7 | Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.   |

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| LA.RL.11-12.8      | (Not applicable to literature)   |
| LA.K-12.NJSLSA.R8  | Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.   |
| LA.RI.11-12.1      | Accurately cite strong and thorough textual evidence, (e.g., via discussion, written response, etc.), to support analysis of what the text says explicitly as well as inferentially, including determining where the text leaves matters uncertain.  |
| LA.K-12.NJSLSA.W   | Writing<br>Text Types and Purposes   |
| LA.RI.11-12.2      | Determine two or more central ideas of a text, and analyze their development and how they interact to provide a complex analysis; provide an objective summary of the text.  |
| LA.RI.11-12.3      | Analyze a complex set of ideas or sequence of events and explain how specific individuals, ideas, or events interact and develop over the course of the text.  |
| LA.K-12.NJSLSA.W1  | Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.   |
| LA.K-12.NJSLSA.W2  | Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.   |
| LA.RI.11-12.4      | Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze how an author uses and refines the meaning of a key term or terms over the course of a text (e.g., how Madison defines faction in Federalist No. 10).  |
| LA.K-12.NJSLSA.W3  | Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.  |
| LA.RI.11-12.7      | Integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.   |
| LA.W.11-12.1       | Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.   |
| LA.W.11-12.1.A     | Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences claim(s), counterclaims, reasons, and evidence.   |
| LA.K-12.NJSLSA.SL  | Speaking and Listening   |
| LA.W.11-12.1.B     | Develop claim(s) and counterclaims avoiding common logical fallacies and using sound reasoning and thoroughly, supplying the most relevant evidence for each while pointing out the strengths and limitations of both in a manner that anticipates the audience's knowledge level, concerns, values, and possible biases.<br>Comprehension and Collaboration |
| LA.K-12.NJSLSA.SL1 | Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.   |
| LA.K-12.NJSLSA.SL2 | Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.<br>Presentation of Knowledge and Ideas  |
| LA.W.11-12.2       | Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.  |
| LA.K-12.NJSLSA.SL4 | Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task,  |

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|                 | purpose, and audience.   |
| LA.W.11-12.2.B  | Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience’s knowledge of the topic.   |
| LA.W.11-12.3.E  | Provide a conclusion that follows from and reflects on what is experienced, observed, or resolved over the course of the narrative.  |
| LA.SL.11-12.1   | Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 11–12 topics, texts, and issues, building on others’ ideas and expressing their own clearly and persuasively.                         |
| LA.SL.11-12.1.A | Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well reasoned exchange of ideas.                      |
| LA.SL.11-12.1.B | Collaborate with peers to promote civil, democratic discussions and decision-making, set clear goals and assessments (e.g., student developed rubrics), and establish individual roles as needed.  |
| LA.SL.11-12.1.C | Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives.          |
| LA.SL.11-12.1.D | Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task. |
| LA.SL.11-12.2   | Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, qualitatively, orally) evaluating the credibility and accuracy of each source.  |
| LA.SL.11-12.4   | Present information, findings and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience.   |

## **Integration of Diversity, Equity and Inclusion; Climate Change; Informational and Media Literacy**

see Crosswalks

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## **21st Century Life and Careers**

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### **Stage I: Desired Results**

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### **Transfer/Overview/Rationale**

## Transfer / Overview / Rationale

### Unit Rationale

The purpose of this unit...

The world is constantly in motion due to forces and students, as part of that world, need to understand what effect these forces have on the movement around them. Understanding motion will provide students the ability to interpret real-world topics such as how travel times are determined, how the design of moving objects affects their ability to move, and what reduces or increases overall forces. Students will be able to solve problems conceptually and mathematically.

## Meaning

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## Essential Questions

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Essential Questions

1. How does the position of an object change based on varying velocities?
2. What factors influence freefall of an object?
3. What happens to an object when it accelerates?
4. When the applied force on an object changes, what happens to the acceleration?
5. What variables influence the degree to which a force affects the structure or stability of an object?

## Enduring Understanding/Indicators of Understanding

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Enduring Understanding/Indicators of Understanding

Students will understand that:

- Velocity changes the position of an object
- The time for freefall is based on the rate of gravity, not mass
- Acceleration is the change of velocity
- Acceleration is the result of a net force
- Objects can be designed to add or reduce impact forces

## **Acquisition (Student Learning Objectives)**

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### **Knowledge**

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Knowledge

Students will know...

Velocity

Speed

Acceleration

Deceleration

Force

Mass

Buoyancy

Friction

Air resistance

Pressure

Fluids

Springs

Torque

Meters

Seconds

Newtons

Center of Gravity

Inertia

Impact

Freebody diagram

## Skills

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### Skills

Student will be skilled at ...

- Evaluate units used in mathematical expression in position, motion, and forces
- Compare velocity and speed
- Predict the position of an object based on velocity and time conditions
- Interpret graphs to make predictions when variables such as position, acceleration, mass, and force are manipulated what the outcome will be
- Explain how rate of freefall is determined (and how it can be changed)
- Support Newton's Laws of Motion through scientific evidence
- Design systems to increase or decrease force on an object
- Construct a system to minimize forces on an object
- Manipulate the structure of a system to maximize buoyancy
- Evaluate the structure of an object to determine center of gravity and stability

- Compare and contrast how friction is influenced based on the material of an object
- Evaluate the forces that hold planets in orbit

## **Stage 3: Learning Plan**

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### **Resource and Mentor Texts**

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#### Resources and Mentor Texts

- Dominiak YouTube Channel for videos with notes:  
[https://www.youtube.com/channel/UC31uEMjXuiA8uPp-esCz6Jw?view\\_as=subscriber](https://www.youtube.com/channel/UC31uEMjXuiA8uPp-esCz6Jw?view_as=subscriber)
- BrainPOP for educational videos, quizzes, activities: [www.brainpop.com](http://www.brainpop.com)
- University of Colorado interactive labs: balancing act, forces and motion, forces in 1 dimension, friction, masses and springs, the moving man <https://phet.colorado.edu/>
- CPO Science lab modules

### **Formative Assessment Strategies**

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#### Formative Assessment Strategies

- Hand Signals - students use hand signals to indicate their understanding
- One-Minute Essay
- Misconception Check - students are presented with a common misconception about a concept and then asked to agree or disagree and explain why.
- Student Conference - one on one conversation with students to check for understanding
- Observation - observe students as they work to check for learning
- Exit Card - written student responses to questions posed at the end of a class or learning activity.
- Topic Assessments - brief quizzes on one or two topics
- Choral Response - students respond verbally at the same time in response to a question
- Debriefing - students reflect on their work immediately following an activity
- White Board Game - groups present “solutions” to practice problems that include an intentional mistake. Other groups must identify the mistake.

## **Learning Activities/Unit of Study**

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### Learning Activities/Unit of Study

- Demonstrations to visualize concepts before teaching with question and answer time for students
  - Center of gravity
  - Elevator rides with scales
  - Balancing
  - Inertia
  - Pressure
- Lecture with notes packet
  - Position, speed, velocity
  - Acceleration
  - Freefall and Gravity
  - Force
  - Newtons Laws
  - Center of Gravity and Balance
  - Pressure
  - Buoyancy
  - Torque
- Videos- clips of media to demonstrate or reinforce topics from the unit
- Labs per topic to include
  - Safety insrucions
  - Hands on activity
  - Analysis questions
- Assessments
  - Lab reports
  - Quizzes
  - Benchmark project

## **Modifications and/or Accommodations**

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### **Suggested Modifications (ELL, Sp. Ed, Gifted, At-risk of Failure)**

#### **English Language Learners**

Native language support: The teacher provides auditory or written content to students in their native language.

Adjusted Speech: The teacher changes speech patterns to increase student comprehension. This could include facing the students, paraphrasing, clearly indicating the most important ideas, and speaking more slowly.

Visuals: The teacher uses graphics, pictures, visuals, and manipulatives. This helps ELL students better understand and comprehend the subjects at hand.

**Front-Loading Vocabulary:** The teacher front loads vocabulary. This means providing students with a list of important vocabulary words they will need to know for a book, lesson, etc. prior to the lesson being taught. Including pictures to go with the vocabulary words is also very beneficial for the students.

## **Special Education Students**

**Chunking:** The teacher presents information in a way that makes it easy for students to understand and remember. Chunking is based on the presumption that our working memory is easily overloaded by excessive detail. The best way to deliver information is to organize it into meaningful units. Because students with special needs get overloaded easily, chunking is an effective strategy to use with them.

**Checking for Understanding:** It is important to constantly check for understanding, especially for students who have accommodations. Teachers want to make sure students understand the concepts being covered in a way that makes sense to them.

**Extra time:** The teacher provides students with special needs extra time to complete work or answer questions. It is important to give students enough time to process their thoughts.

**Oral Reading:** The teacher will read work orally to students. Class work such as tests and literature circles may need to be read aloud to the student.

**Timers:** The teacher will use timers as an instructional tool. The use of timers is beneficial for students who have trouble completing tasks. Timers can be helpful so the student is aware of how much time they have to complete an assignment.

## **Students with 504 Plans**

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## **Gifted & Talented Strategies**

**Extensions/Enrichments:** Teachers will provide gifted and talented students with extension/enrichment projects. Students will be challenged to further their understanding, to apply

acquired knowledge, and/or to produce something in reference to acquired knowledge.

**Modify/Change Activities:** Teachers will monitor and modify activities to accommodate those students who need to be challenged further. Additional reading, problem-solving, writing, or project work is necessary for those students who are ready to move on at a rate more accelerated than their peers. In this way, G & T students are provided the same opportunity for support as special needs students.

## Students at Risk of School Failure

**Directions or Instructions:** Make sure directions and/or instructions are given in limited numbers. Give directions/instructions verbally and in simple written format. Ask students to repeat the instructions or directions to ensure understanding occurs. Check back with the student to ensure he/she hasn't forgotten.

**Peer Support:** Peers can help build confidence in other students by assisting in peer learning. Many teachers use the 'ask 3 before me' approach. This is fine, however, a student at risk may have to have a specific student or two to ask. Set this up for the student so he/she knows who to ask for clarification before going to you.

**Alternate or Modified Assignments:** Always ask yourself, "How can I modify this assignment to ensure the students at risk are able to complete it?" Sometimes you'll simplify the task, reduce the length of the assignment or allow for a different mode of delivery. For instance, many students may hand something in, the at-risk student may jot notes and give you the information verbally. Or, it just may be that you will need to assign an alternate assignment.

**Increase One to One Time:** When other students are working, always touch base with your students at risk and find out if they're on track or needing some additional support. A few minutes here and there will go a long way to intervene as the need presents itself.

**Contracts:** It helps to have a working contract between you and your students at risk. This helps prioritize the tasks that need to be done and ensure completion happens. Each day write down what needs to be completed, as the tasks are done, provide a checkmark or happy face. The goal of using contracts is to eventually have the student come to you for completion sign-offs.

**Hands On:** As much as possible, think in concrete terms and provide hands-on tasks. This means a child doing math may require a calculator or counters. The child may need to tape record comprehension activities instead of writing them. A child may have to listen to a story being read instead of reading it him/herself.

**Tests/Assessments:** Tests can be done orally if need be. Break tests down in smaller increments by having a portion of the test in the morning, another portion after lunch and the final part the next day.

**Seating:** Seat students near a helping peer or with quick access to the teacher. Those with hearing or sight issues need to be close to the instruction which often means near the front.

