# Teacher Toolkit - Position - Velocity - Acceleration

**Objectives:**

1. Students should understand the difference between the terms distance and displacement, speed and velocity, and velocity and acceleration.
2. Students should combine an understanding of these terms with the use of pictorial representations (dot diagrams, vector diagrams) and data representations (position-time and velocity-time data) in order to describe an object's motion in one dimension.
3. Students should relate the distance, displacement, average speed, average velocity, change in velocity, time and acceleration to each other in order to solve word problems.

**Readings:** The Physics Classroom Tutorial, 1D-Kinematics Chapter, Lesson 1

**Interactive Simulations:**

1. Graph Matching Motion Model http://www.compadre.org/osp/items/detail.cfm?ID=10012
   Powerful way to investigate the meaning of shape and slope for 3 types of motion graphs. To set it up correctly requires the student to analyze and interpret computer-generated motion of a blue object moving either with constant velocity or constant acceleration. Next, match the motion by using sliders to set initial position, velocity, and acceleration of an adjacent red object. Last, use sliders to predict the shape of the related velocity and acceleration graphs to give correct straight-line slopes.

**Video and Animation:**

1. Physlet Physics: Position and Displacement http://www.compadre.org/Physlets/mechanics/illustration2_1.cfm
   This short activity lets students compare the animated motion of three Monster trucks.
2. Physics 301 – Analysis of Motion Video http://www.gpb.org/chemistry-physics/physics/301
   Good choice for flipped lesson – this 30-minute video from Georgia Public Broadcasting takes students through the basics of 1-D motion, from displacement through velocity and acceleration.

**Labs and Investigations:** https://www.physicsclassroom.com/lab#1dk

1. The Physics Classroom, The Laboratory, Speedometer Lab
   Students use their concept of speed to determine the average speed of a battery-powered car.
2. The Physics Classroom, The Laboratory, Speedometer Cubed Lab
   Students use their concept of speed to determine the average speed of a battery-powered car using three different methods or tools.
3. The Physics Classroom, The Laboratory, Diagramming Motion Lab
   A ticker tape timer is similar tool is used to analyze the dot diagram of three different types of motion – constant speed, slowing down and speeding up.
4. The Physics Classroom, Shockwave Physics Studios, Name That Motion Activity
   Students confront the challenge of matching the motion and dot diagram for 11 different animations to the appropriate verbal description.

**Minds On Physics Internet Modules:** https://www.physicsclassroom.com/mop

The Minds On Physics Internet Modules are a collection of interactive questioning modules that target a student's conceptual understanding. Each question is accompanied by detailed help that addresses the various components of the question.

1. Kinematic Concepts module, Assignment KC2 - Distance vs. Displacement
2. Kinematic Concepts module, Assignment KC3 – Speed vs. Velocity
3. Kinematic Concepts module, Assignment KC4 – Acceleration
4. Kinematic Concepts module, Assignment KC5 – Oil Drop Representations
5. Kinematic Concepts module, Assignment KC8 – Pos-time and Vel-time Data Analysis

**Conceptual Building Exercises:** https://www.physicsclassroom.com/curriculum#1dk

1. The Curriculum Corner, Describing Motion Verbally with Distance and Displacement
2. The Curriculum Corner, Describing Motion Verbally with Speed and Velocity
3. The Curriculum Corner, Acceleration
4. The Curriculum Corner, Describing Motion with Diagrams
5. The Curriculum Corner, Describing Motion Numerically

**Problem-Solving Exercises:** https://www.physicsclassroom.com/calcpad/1dkin

1. The Calculator Pad, 1D Kinematics, Problems #1-9

**Science Reasoning Activities:**

1. Science Reasoning Resource CD, 1D Kinematics, Stopping Distance

Link: http://www.physicsclassroom.com/reasoning/1dkin

**Physics Education Research:**

1. Kinematics Graph Interpretation Project http://www.ncsu.edu/ncsu/pams/physics/Physics_Ed/TUGK.html
   Recent work has uncovered a consistent set of student difficulties with graphs of position, velocity, and acceleration vs. time. For the busy teacher, this synopsis will be a quick read but worth every minute. It organizes the findings of several years of the Kinematics Graph Interpretation Project on one page.
2. Searching for Evidence of Student Understanding, T. Bartiromo, presented at the Physics Education Research Conference 2010, Portland, Oregon http://www.compadre.org/per/items/detail.cfm?ID=10390
   This research examined whether high school students can translate between representations (an ability often considered to be an "expert trait" in solving physics problems). It also gauged whether requiring multiple representations for a single problem helped instructors better assess student understanding.

**Common Misconceptions and Student Difficulties:**

1. Confusion of Speed and Acceleration
2. The Use of + and – to Describe Direction
3. Confusion about the Direction of Velocity and Acceleration

**See the complete toolkit at TPC's Teacher Toolkit website for details.**

**Standards:**

**A. Next Generation Science Standards (NGSS) – Grades 9-12**
*Note: The topic of kinematics is not directly covered in the NGSS.*

**B. Math Common Core Standards (CC) – Grades 9-12**
**Standards for Mathematical Practice MP.2**, **MP.6**, and **MP.8**
**Quantities: Reason Quantitatively and Use Units to Solve Problems N-Q.1** and **N-Q.3**
**Algebra: Seeing Structure in Expressions – Interpret the Structure of Expressions A-SSE.1.a, A-SSE.2**
**Algebra: Creating Equations A-CED.2** and **A-CED.4**
**Functions: Interpret Functions that Arise in Terms of a Context F-IF.4** and **F-IF.6**
**Functions: Analyze Functions Using Different Representations F-IF.7.a**
**Building Functions: Linear, Quadratic, and Exponential Models F-LE.1.b** and **F-LE.1.c**
**Functions: Interpret Expressions for Functions in Terms of the Situation They Model F-LE.5**

**C. ELA Common Core – High School**
**Key Ideas and Details RST.11-12.2**
**Craft and Structure RST.11-12.**
**Integration of Knowledge and Ideas RST.11-12.9**
**Range of Reading and Level of Text Complexity RST.11.12.10**

**D. College Ready Physics Standards (Heller and Stewart)**
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