Teacher Toolkit - Position-Time Graphs

Objectives:
1. To relate the shape (horizontal line, diagonal line, downward-sloping line, curved line) of a position-time graph to the motion of an object.
2. To relate the slope value of the line on a position-time graph at a given time or during a given period of time to the instantaneous or the average velocity of an object.
3. To use a slope calculation to find the instantaneous or average velocity of an object.
4. To relate the motion of an object as described by a position-time graph to other representations of an object's motion - dot diagrams, motion diagrams, tabular data, etc.

Readings: The Physics Classroom Tutorial, 1D-Kinematics Chapter, Lesson 3

Interactive Simulations:
1. PhET Simulation: The Moving Man   http://phet.colorado.edu/en/simulation/moving-man
   This interactive simulation lets learners move a little man on the screen and view the resulting graphs of position, velocity, and acceleration. It was developed to help beginners explore why the graphs follow predictable patterns. Set initial conditions and view the graphs simultaneously as the "Moving Man" changes position.
2. PhET Supplementary Materials: The Moving Man   http://phet.colorado.edu/en/contributions/view/2828
   Inquiry-based materials developed by the PhET team specifically for use with The Moving Man. This one includes Power Point concept questions (with answers provided), lesson plan, pre-lab and post-lab assessments, and printable student guidelines.
3. Concord Consortium: Describing Velocity   http://concord.org/stem-resources/describing-velocity
   This classroom-tested graphing activity explores similarities and differences between Position vs. Time and Velocity vs. Time graphs. It accepts user inputs in creating prediction graphs, then generates an accurate comparison graph for the process being analyzed. Learners will annotate graphs to explain changes in motion, respond to question sets, and analyze why the two types of graphs appear as they do.

Video and Animation:
1. Physlet Physics: Average Velocity   http://www.compadre.org/Physlets/mechanics/illustration2_2.cfm
   This animation shows the Position vs. Time graph for a car traveling at non-constant velocity. Students can view "Rise and Run" to see that the rise is the displacement and run is the time interval. Click "Show Slope" to see how the slope of the line represents the average velocity. Simple, but packs punch.
2. Position vs. Time and Velocity vs. Time Graphing   https://www.youtube.com/watch?v=0AIuOQevPxI
   For students who continue to struggle with motion graphing after instruction, this video provides help in relating distance traveled and velocity through graph representations. It gives explicit explanations of how to use slope of a P/T graph to determine average velocity, and how to use the area under the curve on a V/T graph to determine the change in position.
3. Bozeman Science: Position vs. Time Graph-Part 1   https://www.youtube.com/watch?v=x2ve5yucNPQ
   For your students with disabilities, English Language Learners, or kids who read below grade level, this video can be a good choice for help in interpreting Position vs. Time graphs. The author is a high school physics teacher from Bozeman, Montana. His easygoing, conversational style keeps it simple, while still introducing the requisite math. This video explores motion of an object with constant velocity.

Labs and Investigations: http://www.physicsclassroom.com/lab#1dk
1. The Physics Classroom, The Laboratory, Position-Time Graphs Lab
   Using a motion detector, students explore the shapes of position-time graphs for various types of motion.
2. The Physics Classroom, The Laboratory, Interpreting the Slope Lab
   Students walk in front of a motion detector with a measureable speed and compare the measured speed to the slope of the line on a position-time graph.

Minds On Physics Internet Modules: http://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 Graphing, Assignment KG1 - Basics of p-t Graphs
2. Kinematic Graphing, Assignment KG2 - Interpreting p-t Graphs (I)
3. Kinematic Graphing, Assignment KG3 - Interpreting p-t Graphs (II)
4. Kinematic Graphing, Assignment KG4 - Slope Calculations

Concept Building Exercises: http://www.physicsclassroom.com/curriculum/1Dkin

1. The Curriculum Corner, 1D Kinematics, Describing Motion with Position-Time Graphs
2. The Curriculum Corner, 1D Kinematics, Describing Motion Graphically
3. The Curriculum Corner, 1D Kinematics, Graphing Summary

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

1. The Calculator Pad, 1-Dimensional Kinematics, Problems #10 - #12

Science Reasoning Activities: http://www.physicsclassroom.com/reasoning/1dkin

1. Science Reasoning Center, 1-D Kinematics, Kinematics

Common Misconceptions and Difficulties

1. Slowing Down vs. Downward Slopes
2. Negative and Positive Acceleration
3. Slope Calculations
   (See the complete toolkit at TPC's Teacher Toolkit website for details.)

Physics Education Research: **(See the complete toolkit at TPC's Teacher Toolkit website for details.)**

1. Kinematics Graph Interpretation Project
   http://www.ncsu.edu/ncsu/pams/physics/Physics_Ed/TUGK.html
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

PER-Based Experiment:

1. Catching Mistakes: The Case of Motion Graphs Classroom Experiment
   http://www.physics.umd.edu/perg/OSTutorials/01_Position_and_Velocity/Tutorial_01_X_and_V.pdf
   (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   A-SSE.1.a   and   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
   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**
   Craft and Structure   RST.11-12.4
   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)**
   (See the complete toolkit at TPC's Teacher Toolkit website for details.)