Teacher Toolkit - Velocity-Time Graphs

Objectives:

1. To relate the shape (horizontal line, diagonal line, downward-sloping line, etc.) of a velocity-time graph to the motion of an object.
2. To relate the slope value of the line on a velocity-time graph at a given time or during a given period of time to the instantaneous or the average velocity of an object and to determine such velocity values using a slope calculation.
3. To relate the area between the line and the time-axis of a velocity-time graph to the displacement of the object and to determine such displacement values using an area calculation.
4. To relate the motion of an object as described by a velocity-time graph to other representations of an object's motion - dot diagrams, motion diagrams, tabular data, etc.
5. To analyze position-time graphs and transpose them into the corresponding velocity-time graphs (and vice versa).

Readings: The Physics Classroom Tutorial, 1D-Kinematics Chapter, Lesson 4

Interactive Simulations:

1. Graph That Motion http://www.physicsclassroom.com/shwave/graphthat.cfm
   This activity challenges students to view 11 different animations and make an effort to match the animation to the appropriate position-time or velocity-time graph. Once 11 matches have been made, students can check their answers, receive feedback, and make adjustments. The activity is accompanied by a Directions page.
2. Two Stage Rocket http://www.physicsclassroom.com/shwave/twostage.cfm
   Students analyze the motion of a two-stage rocket, relating the slope and area calculations to the altitude and acceleration of the rocket. Accompanied by a activity sheet that guides students through the process.
3. Graph Matching Motion Model http://www.compadre.org/osp/items/detail.cfm?ID=10012
   Students analyze and interpret computer-generated motion of a blue object moving either with constant velocity or constant acceleration.
4. PhET Teacher Contributions: Velocity vs. Time Graphs http://phet.colorado.edu/en/contributions/view/2833
   This ready-to-use lesson plan was developed specifically for use with the PhET simulation "The Moving Man". It's designed to help beginning students differentiate velocity vs. time graphs from position vs. time graphs, and also to promote understanding of multiple frames of reference in analyzing an object's motion.
5. Car Race Model http://www.compadre.org/OSP/items/detail.cfm?ID=9999
   This customizable EJS model is designed to help learners visualize the difference between constant velocity and constant acceleration. It features the classic physics scenario in kinematics: a lead car travels at constant velocity on a straight track while a second car moves from rest with constant acceleration in the same direction.

Animation:

1. Physlet Physics: Compare Pos'n-Time and Vel-Time Graphs http://www.compadre.org/Physlets/mechanics/ex2_1.cfm
   Animations depict both P/T and V/T graphs for three Monster Trucks. By analyzing the animations, students reason how initial position and the speed affects the shape of the graph. Comes with a printable worksheet.
2. Physlet Physics: Average and Instantaneous Velocity http://www.compadre.org/Physlets/mechanics/illustration2_3.cfm
   A follow-up to the "Average Velocity" Physlet, this exercise lets students set initial and final times to view rise, run, and slope, with the goal of understanding that as the time interval gets smaller and smaller, the average velocity approaches the instantaneous velocity.
3. Physlet Physics: Determine the Correct Graph http://www.compadre.org/Physlets/mechanics/ex2_2.cfm
   Given a dot diagram of a moving ball, students must identify the correct graph that matches up to the motion of the ball. It also includes a pdf worksheet that engages students in analyzing mistakes.
4. Physlet Physics: Curtain Blocks Your View of the Golf Ball http://www.compadre.org/Physlets/mechanics/ex2_3.cfm
   A Velocity vs. Time graph of a golf ball rolling down a green is displayed and students displayed must analyze the V/T graph to figure out the terrain of the green behind the curtain.
5. Physlet Physics: Set the x(t) of a Monster Truck http://www.compadre.org/Physlets/mechanics/ex2_4.cfm
   This short exercise packs lots of punch, as it lets students explore all 3 terms in the equation $x = x_o + v_o \bullet t + 1/2 \bullet a \bullet t^2$. The resource comes with a printable worksheet in addition to the interactive simulation.

Interactive Digital Homework Problem **(See the complete toolkit at TPC's Teacher Toolkit website.)**

1. Illinois PER Interactive Examples: v vs. t http://research.physics.illinois.edu/per/IE/ie.pl?phys111/ie/01/IE_v_vs_t

Video: **(See the complete toolkit at TPC's Teacher Toolkit website.)**

1. Position vs. Time and Velocity vs. Time Graphing https://www.youtube.com/watch?v=0AIuOQevPxI

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

1. The Physics Classroom, The Laboratory, Velocity-Time Graphs Lab
   Using a motion detector, students explore the shapes of velocity-time graphs for various types of motion.
2. The Physics Classroom, The Laboratory, Match That Graph Lab
   Students walk in front of a computer-interfaced motion detector in an effort to match a provided 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 conceptual understanding. Each question is accompanied by detailed help addressing the various components of the question.

1. Kinematic Graphing, Assignments KG5 – KG11

Concept Building Exercises:

The Curriculum Corner, 1D Kinematics http://www.physicsclassroom.com/curriculum/1Dkin

1. Describing Motion with Velocity-Time Graphs
2. Describing Motion Graphically
3. Interpreting Velocity-Time Graphs
4. Graphing Summary

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

1. The Calculator Pad, 1-Dimensional Kinematics, Problems #13 - #17

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

1. The Physics Classroom: Science Reasoning Center, Kinematics
2. The Physics Classroom: Science Reasoning Center, Velocity-Time Graphs

Common Misconceptions: **(See the complete toolkit at TPC's Teacher Toolkit website.)**

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 http://www.compadre.org/per/items/detail.cfm?ID=10390

Elsewhere on the Web: **(See the complete toolkit at TPC's Teacher Toolkit website.)**

1. Graph Sketching and Recognition http://www.physicsclassroom.com/morehelp/graphs

Standards:

A. Next Generation Science Standards (NGSS) – Grades 9-12 (*Kinematics not covered in HS NGSS*)

B. Math Common Core Standards (CC) – Grades 9-12
Standards for Mathematical Practice: MP.2 and **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.)