Using a Motion Simulator to Support Learning About Linear Functions

TERRI L. KURZ
Arizona State University, USA
terri.kurz@asu.edu

DAVID E. MELTZER
Arizona State University, USA
david.meltzer@asu.edu

Computer simulations can be supportive in helping students explore concepts. Here, a motion simulator is used to contextualize the slope–intercept equation in beginning algebra; the simulator is available on the internet and is free to use for all. The simulator portrays a man "walking" along a horizontal *x*–axis with varying speed and direction, accompanied by position/time and velocity/time graphs to represent the motion. The simulator can assist students as they explore the relationships between the man's motion and the corresponding graphs, along with the mathematical equations associated with the graphs. Emphasis is on how the *y*–intercept relates to a person's starting point and how speed and direction relate to slope. There are three ways to use the simulation: toggling (moving) the man, entering an equation, or entering values. The last two methods create movements that can be modeled by straight lines to which the slope–intercept formula can be applied. Two activities are provided that utilize straight–line graphs to promote a context for understanding the meaning of the components of the slope–intercept formula. Activities are designed for introductory algebra (middle school or early high school content).

INTRODUCTION

Simulations are often used in science, technology, engineering, and mathematics (STEM) to help students visualize phenomena. Simulations can be fruitful because they allow students to make conjectures, run repeated trials, gather data, make adjustments, and iteratively try again. Particularly in mathematics, simulations have a positive effect on student outcomes (Hillmayr et al., 2020). Rakes et al. (2010) conducted a systematic review of educational studies ($N = 82$) that had shown instructional improvements in algebra. They found that technology–based algebra curriculum and the use of technology were two of five categories that improved student achievement.

Using simulations can help students visualize motions that are modeled by equations, and also help them to explore what the components of the equations represent. A free physics–based motion simulation is used to contextualize algebra with a particular emphasis on the slope–intercept formula. For example, in the slope–intercept equation ($y = mx + b$), the value of b can be seen to be associated with the initial position of the man who is shown as moving in the simulation; the value of m can be observed to be associated with the slope of the position/time graph, in which case it represents *velocity*, and also with the slope of the velocity/time graph, in which case it represents the *acceleration*. Two lessons are provided that interactively explore how to use the physics–based simulation to teach slope and *y*–intercept to students as they learn basic algebra. Emphasis is on how the man's starting point and velocity impacts the structure of the slope–intercept equation used to model the motion. Step–by–step instructions for using the simulation are included in the lessons designed for introductory algebra (middle school or early high school content).

This curriculum was designed by integrating movement and technology to provide meaningful contexts to learn key algebraic concepts of slope and rate of change. By engaging in this curriculum, students can experience opportunities to develop the concept of slope in context and understand formulaic meanings for slope. With support of the images, there is a connection between the physical movement and the changes on a position/time graph.

RESEARCH REVIEW

Challenges in understanding the meaning of slope are well documented across a multitude of learners. In relation to eighth and ninth grade students in the United States, Korea and Israel, Greenes et al. (2007) identified difficulties across a multitude of concepts including identifying negative/positive slopes, recognizing scale factors on the axes, describing the connection between speed and time, and a relying on visual perceptions rather than calculations. Algebraic symbolism, or the use of symbols in algebra to represent quantitative situations and to support the communication of ideas (Kieran, 1996; Pitta–Pantazi et al., 2020) can also be quite challenging for secondary students (Molina et al., 2017),

With student challenges of algebra concepts like slope, scale and speed/time connections, teachers need to proactively seek alternative approaches for richer experiences. Technology is generally highly accessible in the United States and, though the use of simulations, can be a cost–effective way to supplement more traditional algebra instruction. Simulations in mathematics can be "defined as a way to simulate a scientific and/or complex system" by embedding mathematical content into an environment (Pan et al., 2022). Using simulations in algebra has been shown to increase students' interest compared to more traditional instruction (Egara et al., 2022). Moreover, simulations can improve students' development of algebraic thinking (de Castro Filho et al., 2021).

For the activities presented here, a specific simulation to support physics instruction is used to contextualize algebra. The simulation used in the lessons is a creation of the University of Colorado, Boulder and is part of the Physics Education Technology (PhET) library (https://phet.colorado.edu/en/simulations/filter?type=html,prototype).The PhET library includes simulations in physics, chemistry, mathematics, earth science, and biology. There are over 100 simulations that are searchable by subject, grade level, and inclusive features with a plethora of language options. This database of simulations is reliable, evolving and well–known for enhancing STEM learning (Wieman et al., 2008). The simulations within the database have been widely researched, generally showing improvements in attitudes, engagement and understanding of concepts (Adams, 2010; Haryadi & Pujiastuti, 2020; Yunzal & Casinillo, 2020),

IMPLICATIONS

To support the development of position/time and velocity/time graphs, an online simulation called The Moving Man was used (https://phet.colorado.edu/sims/cheerpj/moving-man/latest/moving-man.html?simulation=moving-man). An easy way to access the simulator is searching the term "The Moving Man." There are three ways to use The Moving Man simulation: toggling (moving) the man using a mouse or trackpad, entering an equation, or entering values. The last two methods create movements that can be accurately modeled by straight–line graphs and to which the slope–intercept formula may be applied, without the need for estimates of values.

To integrate simulations into a secondary algebra class, there needs to be a purposeful use of the simulation. In other words, activities need to be designed and implemented that encourage the use of the interactive features to support meaningful explorations emphasizing sense making (Hillmayr et al., 2020). Encouraging students to interact with the simulation by testing, evaluating, adjusting and retesting conjectures can support more meaningful simulation experiences. de Castro Filho et al. (2021) recommend three distinct strategies for using simulation technologies to improve algebraic reasoning. Simulations should be used to showcase multiple representations of concepts (i.e., graphs, tables, symbols, images). Second, the manipulation of a character or object should be used to test and evaluate conjectures. Third, artifacts should be produced and collaboratively used and reflected upon.

Toggling

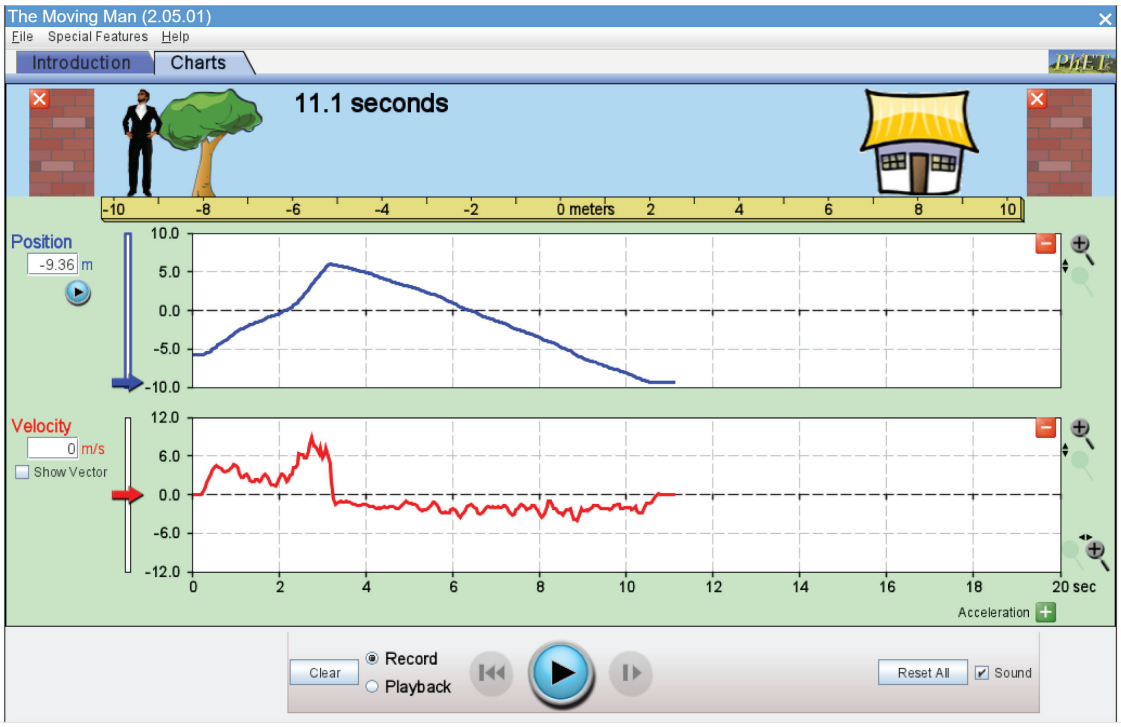
To toggle the man, the mouse or trackpad can be used to move him along the horizonal track by clicking on him and then moving the mouse. There are constraints with this method, as it is impossible to get corresponding motion graphs consisting of smooth straight lines. Therefore, in these cases, graphs of simple equations will not align well with the lines on the motion graphs; see Figure 1. To familiarize students with the features of the simulation, they might be prompted to explore it with the following instructions:

- Click on the "Charts" function to activate the charts, deselect acceleration (if applicable).

- Create a position/time graph with a constant negative slope. What are the values of the slope and *y*–intercept? How do these values correspond to the man's movement?
- Create a position/time graph with a constant positive slope. What are the values of the slope and *y*–intercept? How do these values correspond to the man's movement?
- Create a position/time graph in the shape of mountain that is steep on the left side and less steep on the right side. How is the steepness of the mountain reflected in the slope? How did the man's motion relate to the steepness?
- Create a position/time graph in the shape of three consecutive mountains: a small mountain, a large mountain, and then another small mountain. How is the steepness of the mountains reflected in the slope? How did the man's motion relate to the steepness?
- Describe relationships between the velocity/time graph and the position/time graph.

Figure 1

Position and velocity graph created by toggling (Meltzer, 2023a)



Entering an Equation

Smooth lines can be created in the simulation by entering an equation. To create a movement using an equation, see Figure 2.

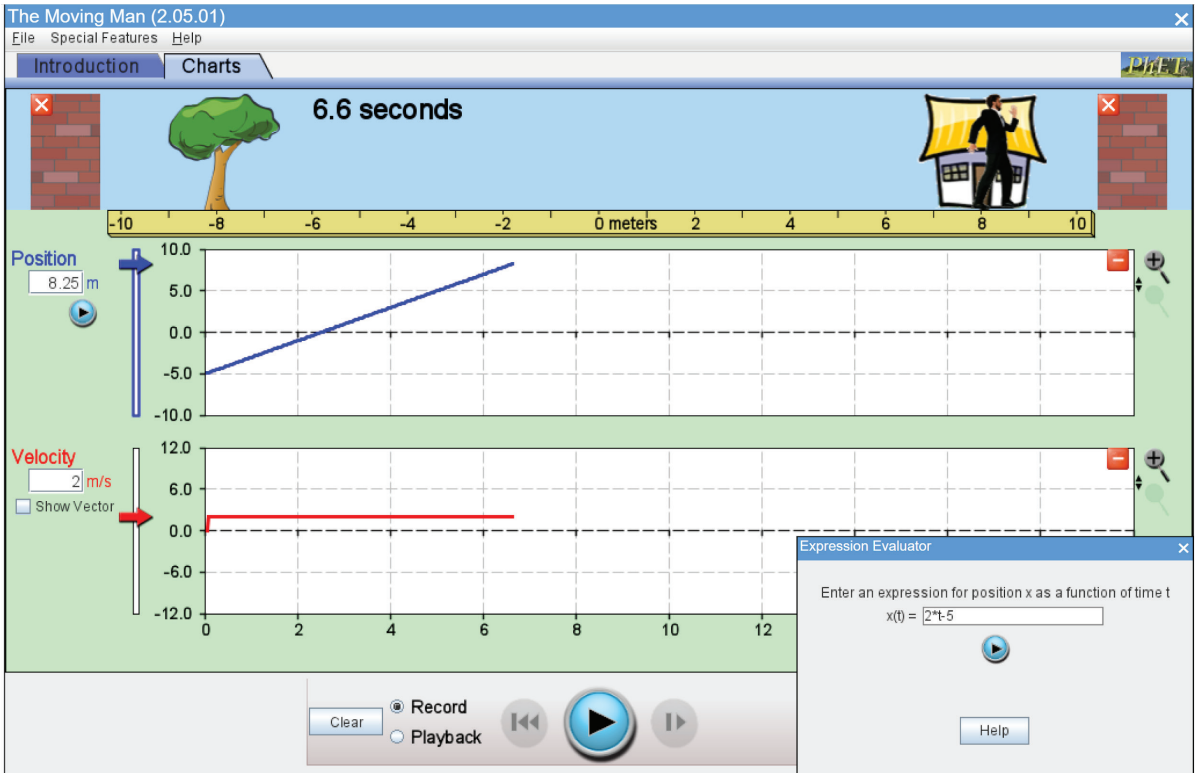
- Click on the "Charts" function to activate the charts, deselect acceleration (if applicable).
- Click on the "Special Features" menu and then on the "Expression Evaluator" function; deselect acceleration (if applicable).
- Enter the function as shown above: 2 * *t* – 5. This is how $y = 2x - 5$ would be entered. Note *t* is used rather than *x*.
- Then, push the play button in the Expression Evaluator box.

Appendix A includes more detailed instructions as well as a worksheet with open–ended questions to support student explorations using equations. To expand on the lesson in the appendix, students can be asked to:

- Create two position–time graphs: one with a constant negative slope and one with a constant positive slope. What are the values of the slope and y–intercept in your two graphs? How do these values correspond to the man's movement? How do negative and positive values influence the slope and *y*–intercept?
- Create a position/time graph that starts at –12 m and progresses to 12 m within an 18–second timeframe. Describe the values of the slope and y–intercept. If the graph starts instead at 12 m and progresses to –12 m in an 18 second timeframe, how is the equation impacted? If the graph starts at –6 m and progresses to 6 m in an 18–second timeframe, how is the equation impacted?
- Enter an equation of your choice that results in a motion lasting longer than 10 seconds. What is the slope and y–intercept of your equation? Examine the corresponding velocity graph. Explain how the velocity graph relates to the equation.
- Enter an equation into the simulator. Once the position/time and velocity/time graphs are created, cover up the position graph with a piece of paper. Ask a classmate to determine the equation you used by looking only at the velocity graph. Is it possible? Explain your reasoning.

Figure 2

Position and velocity graphs created by entering an equation (Meltzer, 2023b)



Entering Values

In addition to equations, values can be entered into the simulation to create straight lines that represent movement. To create lines using values:

- Click on the "Charts" function to activate the charts, deselect acceleration (if applicable).
- There is a box under the word "Position."
- Put a 5 in the "Position" box and a –3 in the "Velocity" box, as shown below in Figure 3.
- Hit Play (the button with a circle).
- Watch the man move, then when he reaches the wall, push the "Pause" button. Try to stop him before he hits the wall and stops.
- After you pause the man, change the "Velocity" to 3 and then again push "Play." Watch the man move, then when he reaches the wall, push the "Pause" button. Try to stop him before he hits the wall and stops.
- Now, switch the velocity to –7 and push play. Pause him before he hits the wall.

Appendix B includes more detailed instructions as well as a worksheet with open–ended questions to support student explorations using values. To expand on the lesson in the appendix, students can be asked to:

- Create two graphs: one with a constant negative slope and one with a constant positive slope. Can an equation be created based solely on the graphs? Explain your reasoning.
- Enter an equation of your choice that generates a motion that lasts longer than 10 seconds. What is the slope and y–intercept of your equation? Examine the corresponding velocity/time graph. Explain how the velocity graph relates to the equation.
- Enter values into the simulator. Once the position and velocity graphs are created, cover up the velocity graph with a piece of paper. Ask a classmate to sketch the velocity graph using the position graph image. Is it possible? Explain your reasoning.

Figure 3

Position and velocity graphs created by entering values (Meltzer, 2023c)

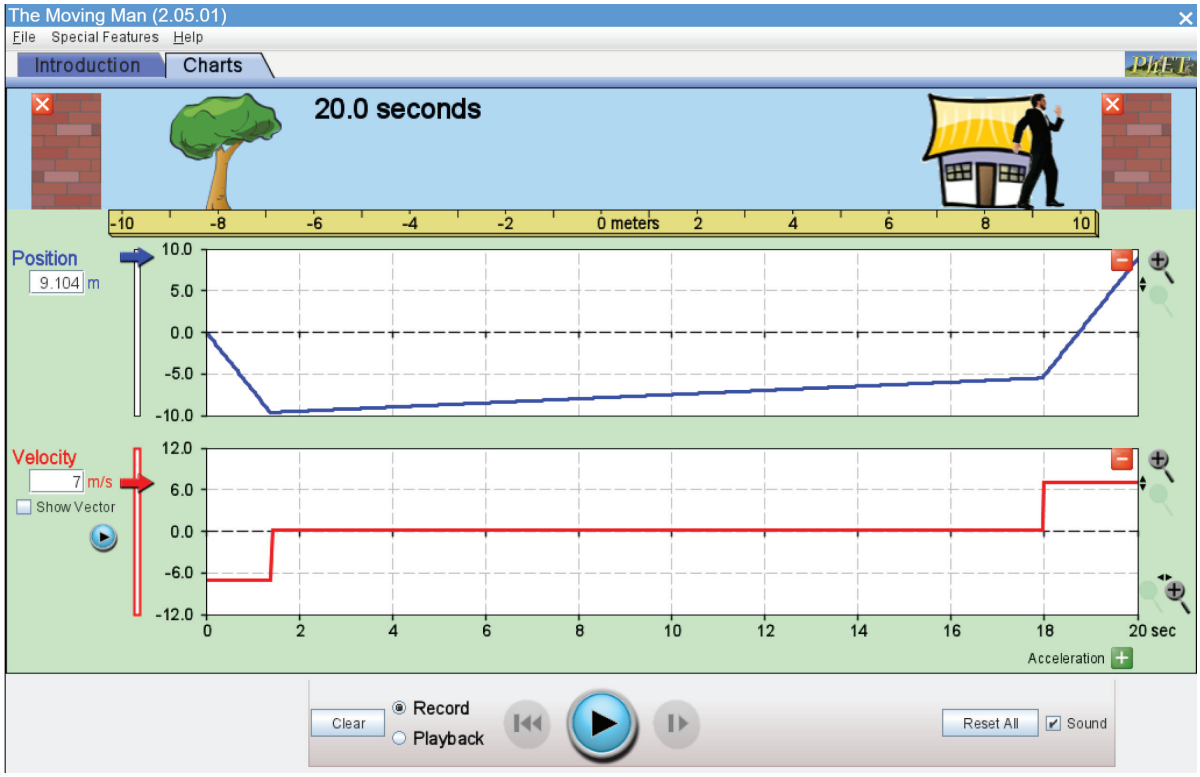
Extension

Creating equations or identifying the values requires a different perspective, perhaps a deeper understanding of the components that influence a position graph and a velocity graph. Students can be challenged to create replicas of graphs by entering equations or entering values. An example from the appendix can be seen in Figure 4. Students can be asked to manipulate the numbers entered into the "Position" and "Velocity" windows, to try to create the given graph. The solution can be found by starting with a zero for position and a velocity of –7 m/s. Then, once the man hit the wall, velocity was changed to 0.25 m/s. Finally, when the man walked for about 18 seconds total, velocity was changed to 7 m/s. Additionally, students can be asked to:

- Create a graph using values and share the graphs with classmates. The values or equations can be covered up. Classmates are then challenged to create the exact same graph by generating their own equation.
- Create a graph using values and share the values with classmates; the graphs can be covered up. Classmates are then challenged to conjecture the shape of, then sketch the graph that will be created by the given values.

Figure 4

Using the graphs, generate corresponding equations (Meltzer, 2023d)



Some general questions to ask for all of the activities include:

- How do you know where to position the man at the start?
- How does slope relate to velocity?
- What does the man's starting position represent?
- How do you know if velocity is positive or negative?
- How do you know what number to try for velocity (a large number or a small number)?
- Can you determine velocity using a formula?

ACKNOWLEDGMENTS

This material is based upon work supported by the National Science Foundation under Grant No. 1855891. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

REFERENCES

Adams, W. K. (2010). Student engagement and learning with PhET interactive simulations. *Il nuovo cimento C*, *33*(3), 21–32.

de Castro Filho, J. A., de Castro, J. B., & Freire, R. S. (2021). Contributions of digital technologies to the development of algebraic thinking at school. In *Mathematical reasoning of children and adults: Teaching and learning from an interdisciplinary perspective* (pp. 219–238). Springer International Publishing.

Egara, F. O., Eseadi, C., & Nzeadibe, A. C. (2022). Effect of computer simulation on secondary school students' interest in algebra. *Education and Information Technologies*, 1–13.

Greenes, C., Chang, K. Y., & Ben–Chaim, D. (2007). International survey of high school students' understanding of key concepts of linearity. In *Proceedings of the 31st Conference of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 273–280). PME.

Haryadi, R., & Pujiastuti, H. (2020, April). PhET simulation software–based learning to improve science process skills. In *Journal of Physics: Conference Series* (Vol. 1521, No. 2, p. 022017). IOP Publishing.

Hillmayr, D., Ziernwald, L., Reinhold, F., Hofer, S. I., & Reiss, K. M. (2020). The potential of digital tools to enhance mathematics and science learning in secondary schools: A context–specific meta–analysis. *Computers & Education, 153*, 103897.

Kieran, C. (1996). The changing face of school algebra. In C. Alsina, J. Alvarez, B. Hodgson, C. Laborde, & A. Pérez (Eds.), *8th international congress on mathematical education: Selected lectures* (pp. 271–290). S. A. E. M. Thales.

Meltzer, D. (2023a). Position and velocity graph created by toggling [image, screenshot]. https://phet.colorado.edu/sims/cheerpj/moving-man/latest/moving-man.html?simulation=moving-man

Meltzer, D. (2023b). Position and velocity graphs created by entering an equation image [screenshot]. https://phet.colorado.edu/sims/cheerpj/moving-man/latest/moving-man.html?simulation=moving-man

Meltzer, D. (2023c). Position and velocity graphs created by entering values [image, screenshot]. https://phet.colorado.edu/sims/cheerpj/moving-man/latest/moving-man.html?simulation=moving-man

Meltzer, D. (2023d). Using the graphs, generate corresponding equations [image, screenshot]. https://phet.colorado.edu/sims/cheerpj/moving-man/latest/moving-man.html?simulation=moving-man

Meltzer, D. (2023e). Setting up the moving man simulation for equations [image, screenshot]. https://phet.colorado.edu/sims/cheerpj/moving-man/latest/moving-man.html?simulation=moving-man

Molina, M., Rodríguez–Domingo, S., Cañadas, M. C., & Castro, E. (2017). Secondary school students' errors in the translation of algebraic statements. *International Journal of Science and Mathematics Education*, *15*, 1137–1156.

Pan, Y., Ke, F., & Xu, X. (2022). A systematic review of the role of learning games in fostering mathematics education in K–12 settings. *Educational Research Review*, 100448.

Pitta–Pantazi, D., Chimoni, M., & Christou, C. (2020). Different types of algebraic thinking: An empirical study focusing on middle school students. *International Journal of Science and Mathematics Education*, *18*, 965–984.

Rakes, C. R., Valentine, J. C., McGatha, M. B., & Ronau, R. N. (2010). Methods of instructional improvement in algebra: A systematic review and meta–analysis. *Review of Educational Research*, *80*(3), 372–400.

Wieman, C. E., Adams, W. K., & Perkins, K. K. (2008). PhET: Simulations that enhance learning. *Science*, *322*(5902), 682–683.

Yunzal Jr, A. N., & Casinillo, L. F. (2020). Effect of physics education technology (PhET) simulations: Evidence from stem students' performance. *Journal of Education Research and Evaluation*, *4*(3), 221–226.

APPENDIX A

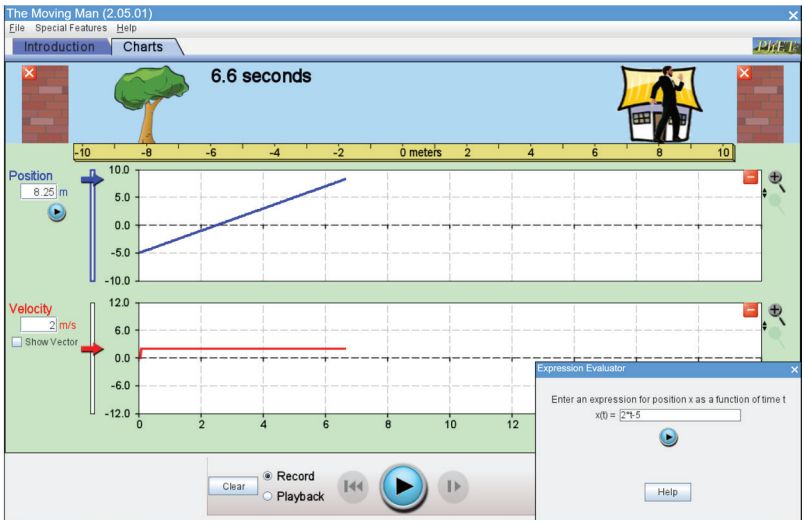
Exploring Equations using the Motion Man Simulation

Using the Simulation with Equations:

1. Open this link: https://phet.colorado.edu/sims/cheerpj/moving-man/latest/moving-man.html?simulation=moving-man
2. Click on the "Charts" function to activate the charts, deselect acceleration of applicable.
3. Click on the "Special Features" menu and then on the "Expression Evaluator" function; deselect acceleration (if applicable).
4. Enter the function as shown above: 2 * t – 5. This is how $y = 2x - 5$ would be entered. Note t is used rather than x.
5. Then, click the blue play button in the Expression Evaluator box seen in Figure 1.

Figure 1

Position and velocity graphs created by entering an equation (Meltzer, 2023b)



6. What does the t represent?
7. What does the –5 represent? How would the graph be different if the 5 was positive?
8. How long did it take to get to the wall near the house?
9. If the 2 became a 4, how would the line look different?

APPENDIX B

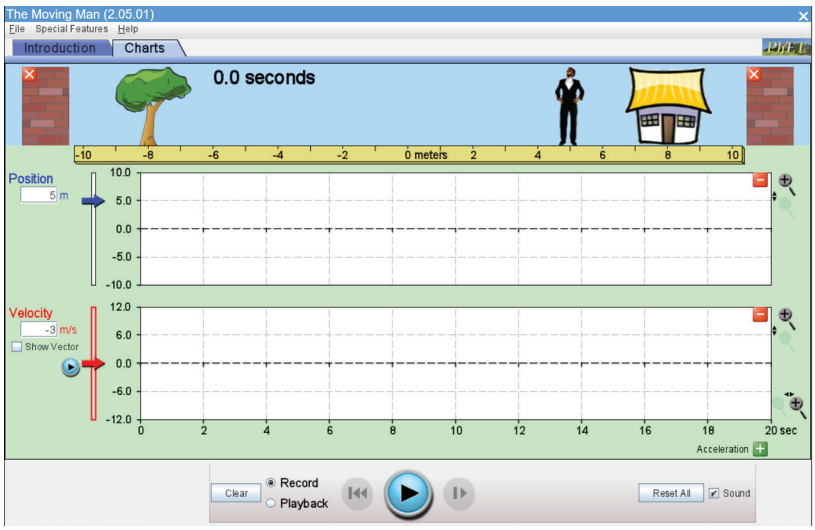
Exploring Values using the Motion Man Simulation

Using the Simulation with Equations:

1. Open this link: https://phet.colorado.edu/sims/cheerpj/moving-man/latest/moving-man.html?simulation=moving-man
2. Click on the "Charts" function to activate the charts, deselect acceleration if applicable.
3. There is a box under the word "Position", see Figure 2.
4. Put a 5 in the "Position" box and a –3 in the "Velocity" box, as shown below.

Figure 2

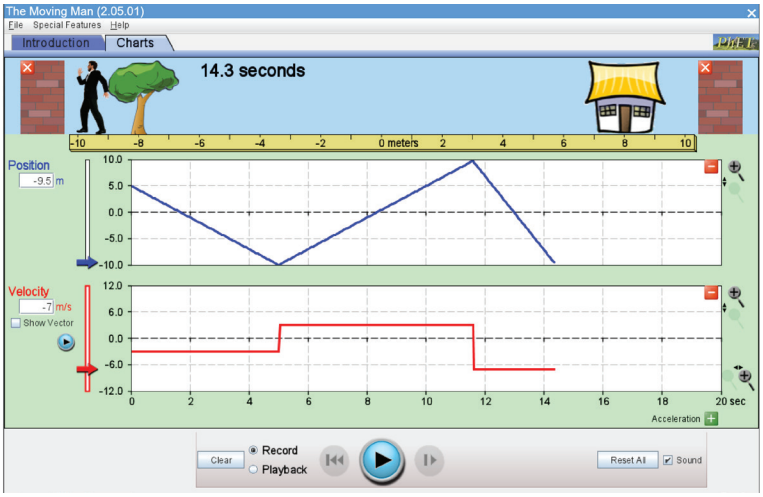
Setting up the moving man simulation for equations (Melzer, 2023e)



5. Click the blue play button. Watch the man move, then when he reaches the wall, push the "Pause" button. Try to stop him before he hits the wall and stops.
6. After you pause the man, change the "Velocity" to 3 and again push "Play." Watch the man move, then when he reaches the wall, push the "Pause" button. Try to stop him before he hits the wall and stops.
7. Switch the velocity to –7 and push play. Pause him before he hits the wall, see Figure 3.

Figure 3

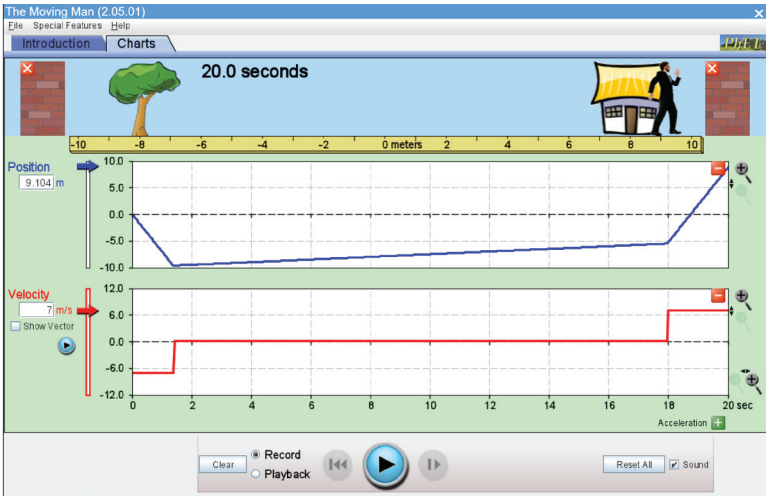
Position and velocity graphs created by entering values (Meltzer, 2023c)



8. Here are some questions to consider:
    a. We changed the velocity from –3 to positive 3, how did that impact the position/time graph? The velocity/time graph?
    b. The position/time graph is steepest at the end; why?
    c. The velocity/time graph has horizonal lines; why?
    d. How do the position/time graph relate to the velocity/time graph?
    e. By manipulating the numbers entered into the "Position" and "Velocity" windows, try to create an image that looks like Figure 4.

Figure 4

Using the graphs, generate corresponding equations (Meltzer, 2023d)



    i. Explain how you created your image.
    ii. How does the number you put into the "Velocity" window impact the graph with the blue line (the position/time graph)?

APPENDIX C

Free Simulations to Support Learning of Algebraic Concepts

Name	Website Address and Description	Algebra I Activities
Graphing Lines	Available: https://phet.colorado.edu/sims/html/graphing-lines/latest/graphing-lines_all.html Allows user to graph straight lines using the point-slope formula and the slope-intercept formula, as well as to play games by creating graphs to match computer-generated equations.	Students can develop understanding of straight-line graphs through a variety of mathematical representations and contexts, by varying the values of slope and intercept and observing the associated changes in the graphs.
Graphing Quadratics	Available: https://phet.colorado.edu/sims/html/graphing-quadratics/latest/graphing-quadratics_all.html Allows user to create graphs of quadratic functions in both standard and vertex form, interactively adjusting coefficients to explore changes in graph structure.	Students can explore graphs of quadratic functions by interactively varying coefficients of terms in the quadratic equation and observing changes in the associated graphs.
Resistance in a Wire	Available: https://phet.colorado.edu/en/simulations/resistance-in-a-wire User can adjust values of variables in the resistance equation $R = \rho L/A$ to observe resulting visual changes in magnitude of R.	Students can explore meaning of direct and inverse proportionality by varying values of one or more of the parameters ρ, L, and A in the resistance equation and observing representations of the resulting changes in magnitude of R.
Equality Explorer: Two variables	Available: https://phet.colorado.edu/sims/html/equality-explorer-two-variables/latest/equality-explorer-two-variables_all.html Allows user to create and solve two-variable equations by varying coefficients and observing effects on a "balance scale" that compares the two sides of the equation.	Students can explore the meaning and structure of two-variable equations by finding solutions when the form of the equation is fixed or by modifying the form of the equation when the solutions are fixed.
Gravity-Force Lab	Available: https://phet.colorado.edu/en/simulations/gravity-force-lab User can explore Newton's Law of Universal Gravitation $F = m_1m_2/r^2$ by varying values of the masses m_1 and m_2 as well as the separation distance r. Resulting magnitude of force F is represented by the lengths of vector arrows.	Students can explore meaning of quadratic and linear variation by selectively varying parameters in the gravitational force law and viewing representations of the resulting magnitude of the gravitational force.

What PreK–12 Teachers Should Know About Educational Technology in 2023: A Research-to-Practice Anthology

Edited by
Richard E. Ferdig, Richard Hartshorne, Emily Baumgartner,
Regina Kaplan-Rakowski, and Chrystalla Mouza

What PreK–12 Teachers Should Know About Educational Technology in 2023: A Research-to-Practice Anthology

Edited by:

Richard E. Ferdig
Richard Hartshorne
Emily Baumgartner
Regina Kaplan-Rakowski
Chrystalla Mouza

Published by
AACE – Association for the Advancement of Computing in Education

Thanks to our family, friends, and colleagues who supported us, the authors who went through a fast but rigorous publication process, the reviewers who reviewed manuscripts, and all the teachers, teacher educators, teacher professional developers, administrators, and students who continue to do educational wonders.

But test all things.
Hold on to what is good.
1 Thessalonians 5:21 (CSB)

What PreK–12 Teachers Should Know About Educational Technology in 2023: A Research-to-Practice Anthology Instruction by Association for the Advancement of Computing in Education (AACE) is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, except where otherwise noted.

Copyright © Association for the Advancement of Computing in Education (AACE). 2023 http://aace.org, email: info@aace.org

Published in and distributed by LearnTechLib—The Learning and Technology Library:
https://www.learntechlib.org/p/222690/

Please cite as:
Ferdig, R. E., Hartshorne, R., Baumgartner, E., Kaplan-Rakowski, R., and Mouza, C. (Eds). (2023). *What PreK–12 Teachers Should Know About Educational Technology in 2023: A Research-to-Practice Anthology*. Association for the Advancement of Computing in Education (AACE). https://www.learntechlib.org/p/222690/

ISBN: 978-1-939797-72-8

TEXT: The text of this work is licensed under a Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) (https://creativecommons.org/licenses/by-nc-nd/4.0/) IMAGES: All images appearing in this work are licensed under a Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) (https://creativecommons.org/licenses/by-nc-nd/4.0/)

The artwork on the front cover was created by Mohamed Hassan and permission was given via a Creative Common License – CC0.

Table of Contents

Preface 7

Accessibility and Inclusion

Activating Universally Designed Supports in One-to-One Learning Environments: Low Investment, High Reward
Andrea Harkins-Brown, Lisa Carey, Hillary Goldthwait-Fowles, Jennifer Kouo, and Eric Moore 21

Applying Universal Design for Learning: A Practical Approach for Planning Equitable Learning Experiences with Classroom Technology
Kerrigan Mahoney and Laura Belle Nelson 27

Assistive Technology in the Classroom: A Case for Teacher Professional Development
Marla J. Lohmann and Matthew Taylor 39

An Educational Focus on Women in STEM and Technology
Grace Morris 45

Girls Just Wanna STEM: Active Engagement and Mentorship in a Middle School STEM Class for Girls
Jillian R. Powers, Ann T. Musgrove, and Susannah L. Brown 51

Breaking Out the Immigrant and Refugee Experience: Integrating Digital Escape Games with Children's and Young Adult Literature
Andrea Paganelli, Xiaoxia Huang, and Jeremy Logsdon 59

Artificial Intelligence

Helping PreK–12 Teachers Overcome the Fear of Artificial Intelligence
Eric Ling, Enrico Gandolfi, and Richard E. Ferdig 71

The PreK–12 Educational Benefits of AI-Based Image Generation
Richard E. Ferdig, Enrico Gandolfi, and Eric Ling 81

Applications of Chatbot and VR in 5–12 Education
Jie Cheng 97

Generative AI Writing Tools: How They Work, What They Do, and Why They Matter
Lucinda McKnight and Troy Hicks 117

Generative AI Technology to Support High School Students Experiencing Challenges With Writing
Kirsty Young and Damian Maher 123

Embracing ChatGPT in Foreign Language Writing Classes: Potentials and Challenges
Arzu Ekoç Özçelik and Zennure Elgün Gündüz 133

Misuse of AI (Artificial Intelligence) in Assignments: Can AI-Written Content Be Detected?
Ferit Kiliçkaya and Joanna Kic-Drgas 145

Content Area Foci

Embracing a Technology-Enhanced Active Learning Mathematics Classroom
Angie Hodge-Zickerman and Cindy York 153

Middle School Mathematics Lessons Emphasizing Art and Modeling Using Visual Computing
Terri L. Kurz, Feyza Kurban, Suren Jayasuriya, and Kimberlee Swisher 159

Enhancing the Mathematics Curriculum With Technology
Mary Miller and Scott Courtney 167

Podcasting Readers Theatre: Engaging Work; Accelerated Results
Sheri Vasinda, Julie McLeod, and Ashley Valencia-Pate 181

Reading and Writing Digital Texts: Gaining Traction With Digital Literacies Footholds
Elizabeth (Betsy) A. Baker 189

The Tip of the Digital Literacies Iceberg: Digital Writing Integration for Elementary Literacy Educators
Kaira Kelly-Howard, Vassiliki Zygouris-Coe, and Nicole Damico 197

Idiomatics, Technology, and Teacher Education: Digital Proposals for Enhancing Instruction in the Digital Era
John I. Liontas 205

Tangible Technologies: Opportunities and Implications for Junior High School Teachers to Connect Practice, Curriculum and Pedagogies
Abbey MacDonald and Suzanne Crowley 221

Gaming, Extended Realities, and Robotics

Finding, Evaluating, and Using Digital Math Games to Engage and Enhance Student Learning
Kristy Litster, Christina W. Lommatsch, and Patricia S. Moyer-Packenham 231

Using a Motion Simulator to Support Learning About Linear Functions
Terri L. Kurz and David E. Meltzer 241

Digital-Based Video Games and 21st Century Skills
Grace Morris 253

Education + Minecraft = Engaging, Creative, & Fun
Dan Stitzel and Grace Morris 261

Augmented Reality: Expanding Our Pedagogical Toolbox to Teach Elementary Science Topics
Sumreen Asim and Joshua Ellis 267

Exploring Student Creation of Virtual Reality Utilizing 360 Video
Emily Baumgartner 277

Enhanced Team-Based Interactive Learning Activities Using the Makey-Makey Board
Jorge Eduardo Ibarra-Esquer and Brenda Leticia Flores-Rios 283

Creating Meaningful Learning Experiences With Button-Operated Robots in Early Childhood Settings
Jacob Hall and David Mulder 293

Social Emotional Development and Interactive Learning

No Worries! Addressing Anxiety Through Educational Technology
Laurie O. Campbell and James Rujimora 307

Bridging Connection Through Technology: How Teachers Can Support Learners With Cancer
James Rujimora and Laurie Campbell 313

Exploring Elementary School Teachers' Experiences of teaching Social and Emotional Learning with Digital Technology
Filiz Zeybek 317

"How Do We Know Technology Can Help Us Teach This?': Using the Technological Instructional Overhead Inventory to Evaluate the Cognitive Load of Technology Adoption.
Colby Tofel-Grehl, Tyler Hansen, and David Feldon 329

Developing a Self-Directed Learning Program for Technology Learning
Colin Talbot 337

Decentralizing Educational Technology Research: Empowering PreK–12 Teachers to Become Action Researchers in Their Own Contexts
Adrian Ting 345

Interactive Teaching With Technology
Dan Niessen 355

Using Technology To Effectively Improve Formative Assessments
Jacob Morella and Enrico Gandolfi 373

K–12 Online and Blended Learning

Using Makerspaces to Create and Produce Mathematics Manipulatives
Karl W. Kosko, Joanne Caniglia, and Maryam Zolfaghari 379

Teaching for Creativity with 3D Printing and Design Thinking
Megan Brannon 387

Getting Teachers Truly Prepared for PreK–12 Online and Blended Instruction
Michael K. Barbour, Charles B. Hodges, and Richard E. Ferdig 395

The Blended Teaching Journey: Research, Resources, and Guidance for Successfully Navigating Blended Environments
Jered Borup, Michelle Jensen, Cecil R. Short, Karen Arnesen, Leanna Archamabualt, and Charles R. Graham 407

Accessing and Integrating Openly Licensed Digital Materials for Teaching and Learning
Kelly Arispe and Amber Hoye 417

What Teachers Should Know About Online Education Resource Marketplaces
Catharyn Shelton and Leanna Archambault 427

Classrooms With and Without Walls: Intentionally Blending In-Person and Virtual Learning Spaces
John Gonzalez and Lorna Gonzalez 437

A Summary of Key Takeaways from Research Using Online Tutors in Elementary Math and Reading for Grades 3–5
Dan A. Keast and Michelle S. Keast 449

AACE Publications
aace.org/pubs