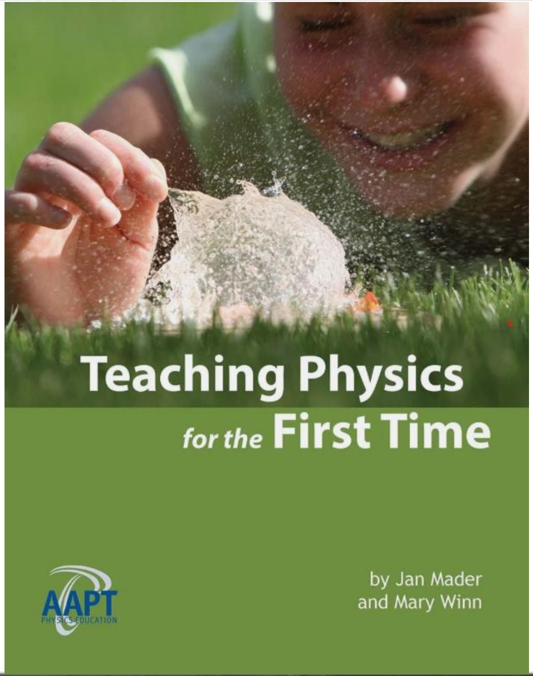
Teaching Physics for the First Time

Jan Mader and Tommi Holsenbeck
A learning cycle approach to teaching physics concepts for new and seasoned teachers of Physics and Physical Science



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Kinematics of Uniform vs Accelerated Motion a 5 E Learning Cycle

Learner Objectives

Students will:

- collect and analyze uniform motion data from a dune buggy and nonuniform motion with a pull back racer.
- identify dependent and independent variables.
- create large graphs that can be easily interpreted by using adding machine tape.
- Interpret graphs of position vs. time, velocity vs. time, and acceleration vs. time for uniform motion and nonuniform motion, including slopes and areas under the graph.

Standards Alignment

- **NGSS** 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.
- **CCSS 3.MD.B.3** Draw a scaled bar graph to represent a data set.
- **CCSS.Math.Content.HSS-ID**: Interpreting Categorical and Quantitative Data
- **CCSS.Math.Content.HSS-ID.A**: Summarize, represent, and interpret data on a single count or measurement variable

Background and Misconceptions

Kinematics, the study of motion, is typically the first area of physics content addressed in most high school curricula. Although many students have a rudimentary understanding of motion, they may be unable to differentiate among the terms describing an object's motion as either uniform or nonuniform.

Common Kinematics misconceptions

Velocity is the same concept as speed.

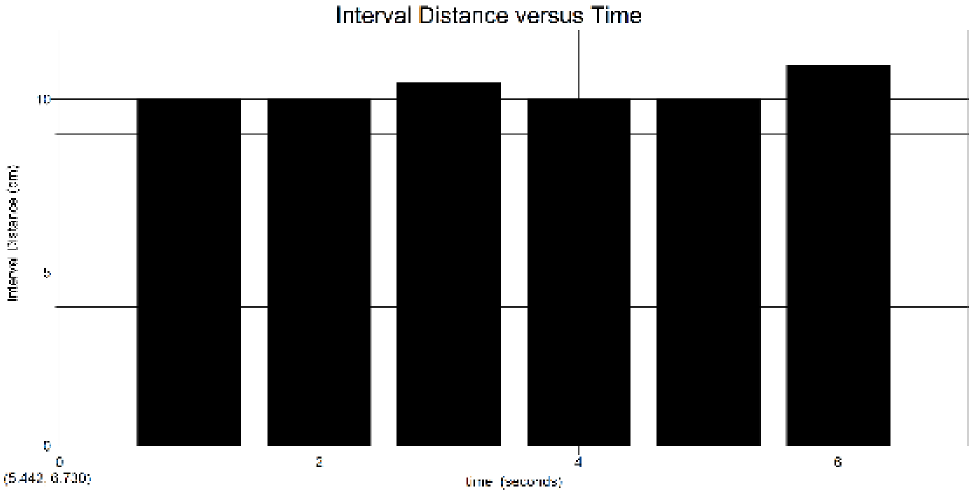
Two objects at the same position have the same velocity.

Velocity and acceleration mean the same thing.

Acceleration and velocity are always in the same direction

An object with no velocity can have no acceleration.

Engage



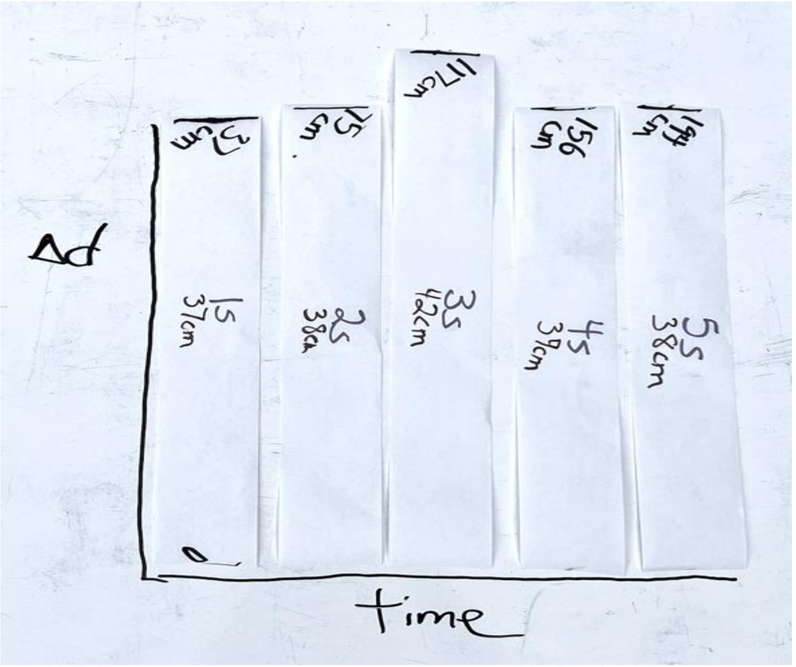
The interval distance versus time graph shown is of a toy car moving to the right.
What interpretation could be given to this car's motion?

Explore

- Use the paper strips or machine tape to mark the distance a constant speed dune buggy travels each interval of time.
- Have a lab group of 6 to 8 students.
- A timer
- A Buggy driver
- 4 to 6 markers spread along the 2 – 3 m tape. Markers place a washer, sticky note or mark with a sharpie at the location of tires when told by the timer to do so.
- **Note**: it may take more than one trial to get the rhythm and marking synchronized.
- When students have successfully marked tape, have students, cut and measure tape.
- Have students make a graph with the interval tapes by taping strips to the wall or table surface

Explain

- Compare your interval strips within your group and with other lab groups. How are the strips similar? How are the strips different?
- What might account for the discrepancies with length.
- What conclusions can be made from the data that has been collected? Cite evidence to support your conclusions.
- Based on the respective interval lengths per time interval, how would one define average velocity per interval?



Explain

1. What mathematical relationship does the velocity in cm/s indicate?
2. Using the measured data in the previous data table complete a calculated data table

Calculated Data

Time interval (s or count)	Interval distance cm	Interval velocity cm/s	Total distance cm	Velocity for total distance cm/s
0	0	0	0	0
1				
2				
3				
4				
5				
6				

Teacher Notes/Definitions

- Note the graphs will appear relatively "constant" or "consistent" in the distance they travelled during any time period. This means the dune buggy was not accelerating because it was travelling the same speed and covering the same distance during each time interval, much like having a cruise control set on an automobile.
- Acceleration is **nonuniform motion**.
- *NOTE:* The change in distance (Δd) is NOT the same as **total** distance travelled. This is an interval velocity vs. time graph.
- $V_{interval} = (\Delta d/\Delta t)$. To find the distance travelled, one would multiply the average velocity x Δt *or* $d = vt$.
- Plotting the total distance travelled would show that the total distance increased each second because the object was farther down the path being travelled. This would be a linear graph.

Equation Derivations

- Velocity is the change in distance (i.e. y-axis) divided by the change in time (i.e. the x-axis). In the above example, the car traveled 37 cm in the first second so the Δd=37 cm and Δt = 1. Velocity =($\Delta d/\Delta t$)*, so the velocity at the end of the first second is 37cm/sec and the car traveled a distance 37 cm. One could also say the car was displaced 37 cm from the starting point.*
- For the second time period, the car traveled 38 cm, so the Δd=38 and t=1. Since velocity =*($\Delta d/\Delta t$) the car's velocity is 38 cm/sec for the 2nd period of time and the car traveled an additional 38 cm. The car is now displaced 75 cm from the starting point.*
- *If you want to know the average velocity you take the total change in distance and total time, so it would be* $V_{av} = (\Delta d/\Delta t) = (75cm)/2\ sec. = 37.5cm/sec$
- If one wanted to use the graph to determine how far the car travels in each amount of time, one can take the area of the strips (length x width) or Δd*t. To get the total distance traveled during the first two seconds, one would add the distances (37cm + 38 cm = 75cm).

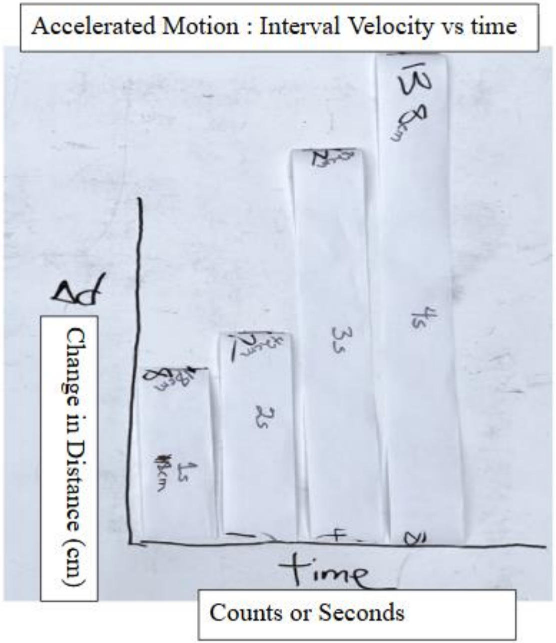
Extension With Pull Back Racer

- Secure 3 m of adding machine tape to the floor.
- Using a Pull back racer wind the spring
- Assign tasks to members of the lab group.
  - Person 1 timing for the experiment. This person will approximate time intervals by either tapping or counting. Cadence must be consistent. The timer will audibly instruct markers and starter. This time frame may need to be reduced due to the acceleration of the car.
  - Person 2 places the car at the starting position when directed. This person will be responsible for releasing the car
  - 5 or 6 “markers. These members are spaced along the tape. As the car approaches a location the person will place a washer or a sticky note at the front of the car as the car passes their location and when the timing person instructs them to do so. Note: as the object accelerates students will need to move along the tape to record data for successive intervals.
- 4. Using scissors cut the paper tape at the location of the washers/sticky notes.
- 5. Measure the respective lengths for the time intervals.
- 6. Record the interval lengths and total length on a data table for calculations.
- 7. Construct a graph by taping sections successively

Measure data for pull back racer

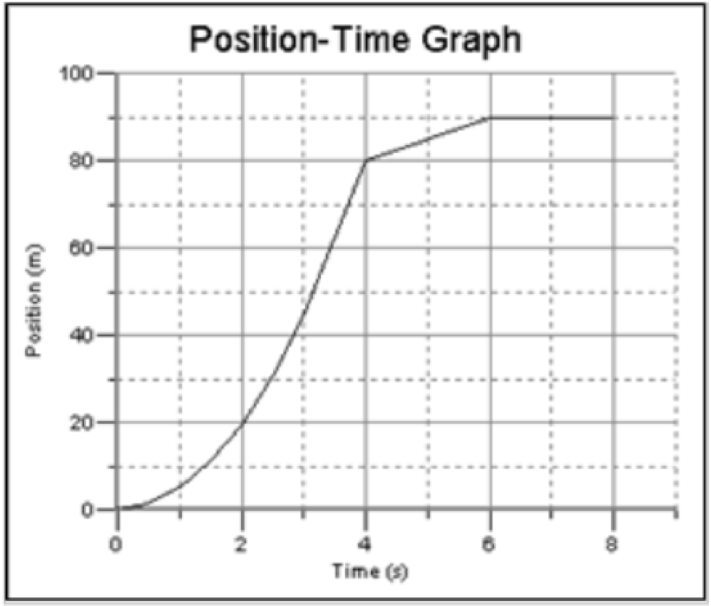
Acceleration is nonuniform motion.
NOTE: The change in distance (Δd) is NOT the same as total distance traveled. This is a velocity vs. time graph because velocity =(Δd/Δt). To find the distance traveled, one would multiply the average velocity x Δt or d=vt. Plotting the total distance traveled would show that the total distance increased each second because the object was farther down the path being traveled.

The graph shown is a sample graph for accelerated motion. This would mean the object (car) would travel more and more distance each second.



Evaluation:

Using the graph describe the motion of the three segments using the terms, constant motion, accelerated motion and no motion. Justify responses.



Tumble Buggy Practicum Crash Up Derby

Students will be given two tumble buggies with different speeds.
Once students have determined the speed of each tumble buggy the instructor will give the students a separation distance.
Students are to calculate the location and the time when the tumble buggies will “crash”.
Students test their predictions and determine the percent accuracy and explain any discrepancies in the results.

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Examples of Additional activities

4.8 Equal Time Equal Distance

Follow the instructions located on pages 73 – 75 and construct the two strings with washers. This may be a teacher demonstration or a mini lab

Description

The accelerated motion of free fall is demonstrated with washers tied to two strings and dropped onto a metal pan. One string has washers tied in five equal distances, and the other string has the washers tied in equal time increments.

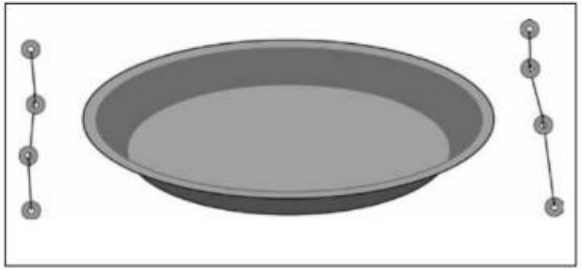

Fig. 4.11. Metal pan and washers for free-fall demonstration.

7.8 Toying Around With Impulse

Using the instructions found on pages 170 – 171 Determine the velocity of a "popper" as it leaves the table. This lab may be used as an extension or evaluation. Additionally add Newton's second law and the Impulse concepts, students could calculate the force of the popper on the table and the time of contact.

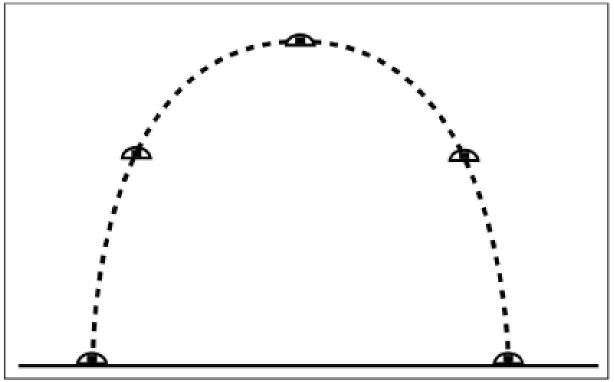

Fig. 7.6. Flight of popper.

8.3 Rainbow Glasses and the Inverse Square Law

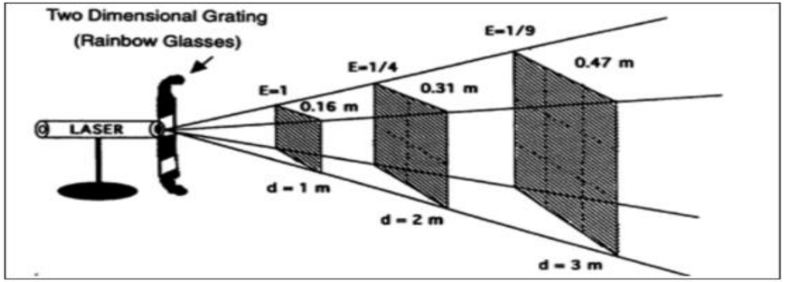

Fig. 8.3. Illustration of the inverse square law.

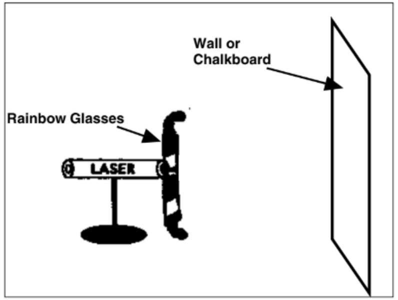

Fig. 8.4. Setup for inverse square law mini-lab.

Pages 180 – 183

To illustrate the relationship between distance and intensity for a quantity that obeys an inverse square relationship.

Follow the safety rule suggestion of belly buttons or lower when using lasers in the classroom.

10.7 Toying around With Energy

Pages 222-223

Use the “poppers” and the conservation of mechanical energ e
velocity of the popper as it leaves the table.
Students are only allowed to measure the height to which the popper jumped to calculate the “popper’s” velocity.

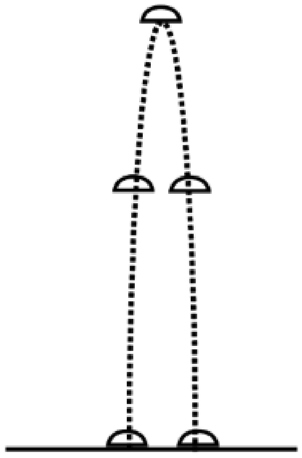

Fig. 10.8. Flight of popper.

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14.5 Standing Wave Demonstrator

Pages 317 – 318

Follow the instructions to make a standing wave generator.

Have students identify nodes and antinodes produced.

How many waves can be produced on the String?

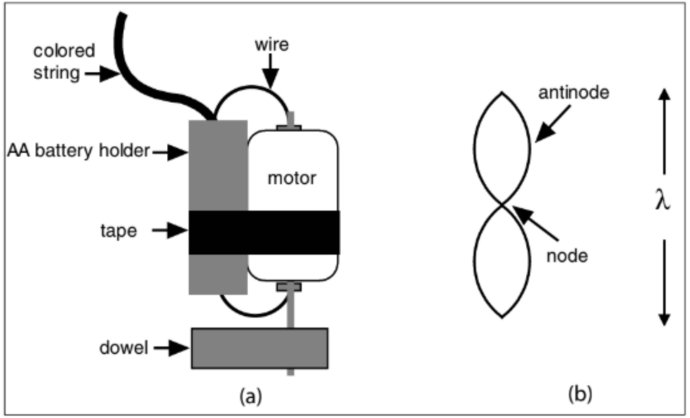

Fig. 14.7. (a) Standing wave demonstrator and (b) standing wave.

15.13 Polarization: Cool Colors with Cellophane Tape

Page 377:
Using Cellophane tape (the cheap variety not scotch brand) create a pattern by crisscrossing layers. View the birefringent pattern by using 2 polarizers.

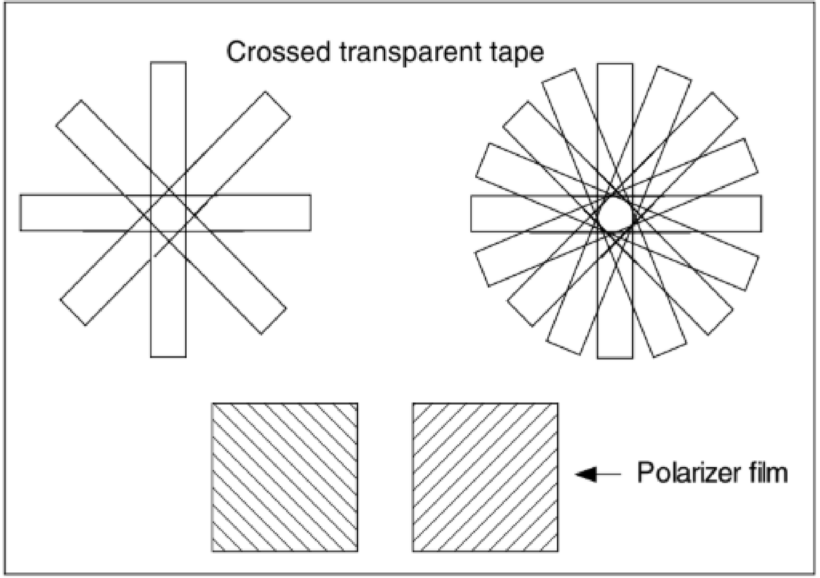

Fig. 15.20. Layers of transparent tape are placed between two pieces of polarizer film.

15.14 Color Me Confused

Pages 378 – 379

Using LEDs and a button battery, students can individually explore the properties of color addition without the use of projectors as a classroom demonstration or mini lab

Thank you for coming

If you have questions or would like more information, please feel free to contact me.

janlandismader@gmail.com

406 – 788 – 6354

Remember physics is phun and can be taught to everyone conceptually. Plus, the learning cycles are intended to use toys, because no one can fear a toy. My students remind me that the one with the most toys wins and I always win.

Jan

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