Throughout the guide teaching tips are in red.

Activity Description and Estimated Class Time

This 2-day activity introduces students to the basics of measuring and graphing motion. Students run a rubber band-powered wooden car along a course where distance is marked. Using timers, students determine how long it takes the car to travel each distance. Afterwards, students graph the data. From the class's graphs students explain:

- The time when a car reaches a specific distance
- The location of a car at a particular time
- The average speed of the car from start to a given location
- The average speed of the car at a given time

Objectives

Students will make and interpret distance/time graphs showing:

- Average speed
- Variable motion
- Change in position over time
- Graphing and interpreting graphs of position versus time.

Correlations to North Carolina Science Standards

7.P.1.3 Illustrate the motion of an object using a graph to show a change in position over a period of time.

7.P.1.4 Interpret distance versus time graphs for constant speed and variable motion.

Brief Science Baground

Anything that is moving is at a different place each moment. Its movement can be described in great detail by listing those places in terms of distance and the times that an object was there. The object's average speed might be described by the distance traveled from one location to another divided by the time it took to get between the two places. These data about motion are easily assembled and graphed. A graph of distance over time can show all of the things listed above including average speed and both constant and variable motion. This activity provides opportunities for students to gain experience and practice both making graphs and interpreting stories that graphs tell about motion.

Part 1 – Graphing Speed Trials

Materials and Procedures

Materials for the whole class

- Masking tape
- Tape measure
- Marker*
- Ability to project from a document camera*

*supplied by the teacher

Materials for each team of 6

- 1 car with wide rubber bands on the wheels (#62)
- 1 medium-sized skinny rubber band (#33)
- 5 timers
- 1 copy Support Document 1 (Time and Distance Data Table)
- 6 copies of Support Document 2 (Time and Distance graph)
- Science notebook*

*supplied by the teacher

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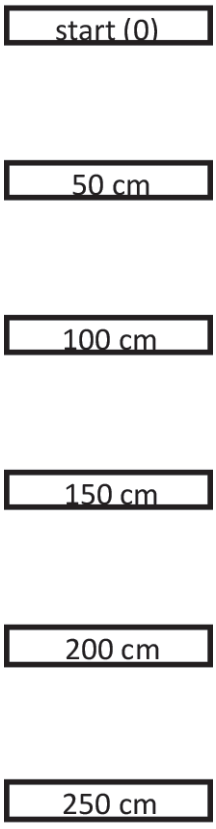
Preparation

1. For each team of 6 students, use the tape measure to lay masking tape strips at 50 cm intervals on the floor. Mark tapes with distance from the starting point as shown:

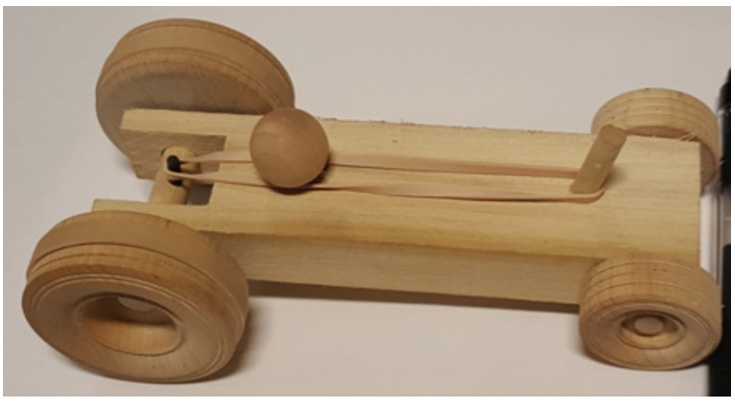


2. Make 1 copy of Support Document 1 for each team.
3. Be ready to demonstrate and project how to wind the rubber band car.
4. Make one copy of Support Document 2 for each student.
5. Prepare the cars by placing the wide (#62) rubber bands on the back wheels as shown in the illustration.

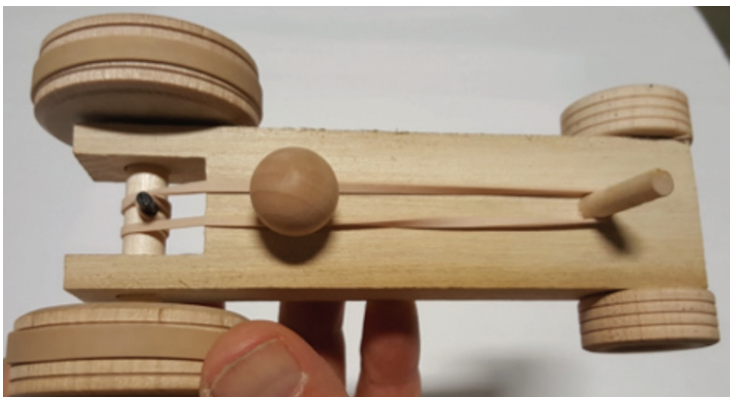
Procedure

1. Form teams of 6. Explain that each team will time a car's movement from a starting point to various distances and record the results.
2. Let teams get all of the materials they will need, including the car, timers, and rubber band.
3. Tell teams that 5 of them will be timers, and that one of them will release the car and record data.

   Give one timer to each team member who will be a timer and show them how to use it. To be accurate, the person timing needs practice. Practice as follows: tell the timers to start when you clap and stop when you clap again. Clap twice with a few seconds between, and ask each person to call out the time recorded (to 0.01 seconds) between claps.Write the times for all to see. Practice until the times get close to half a secondapart.
4. Demonstrate winding the car. Hold up the car and the rubber band. Hook the rubber band over the front post and around the ball so that all can see this (under the document camera if necessary). Place the rear axle under the document camera and hook the rubber band over the dark pin in the axle as shown in the illustration:



Wind the axle one full turn (as shown in the illustration below) and explain that this is one turn.



Then wind it three more turns (four turns total) and ask everyone to wind up the car four turns, exactly as you have done.

5. Ask the teams to go to where you have laid out tapes on the floor.
6. Five of the team members will serve as timers. Ask these students to stand individually with a timer next to one of the five non-starting tapes on the floor. The remaining student will be at the starting tape with Support Document 1. Ask that student to wind the car 4 turns and hold the back wheels from turning. Place front wheels in the middle of the starting tape pointed toward the other tapes. Ask teams to work out how they will start all of their timers exactly when the car starts to roll. Allow a few minutes for this.
7. Ask the teams to practice timing the car from start until it reaches each tape. Allow a few minutes to work this out.
8. When all teams let you know they are ready, project Support Document 1 and show how to fill it out.
   - Ask all teams to do 5 trials, always with 4 turns of the back wheel.
   - Ask all teams to record all 5 trials on Support Document 1.
   - When they finish, ask them to circle the median time (middle value) at each distance.
   - Ask each student in the team to make their own table of the median time at each distance in their science notebook.
9. Ask students to return to their seats. Explain that everyone, individually, will graph these median times from the tables they made on Support Document 2 (Time and Distance graph). Allow 5-10 minutes for students to do this.
10. Discuss how the graphs represent what students saw when their car moved.

Part 2 – Distance/Time Graphs

Materials and Procedures

Materials for the whole class

- Masking tape
- Tape measure
- Marker*
- Sample graphs and the ability to project them*
- Ability to project Support Document 3

*supplied by the teacher

Materials for each team of 6

- Masking tape
- 1 car with wide rubber bands on the wheels (#62)
- 1 medium-sized skinny rubber band (#33)
- 5 timers
- 1 copy Support Document 1 (Time and Distance Data Table)

Materials for each student

- Individual student graphs from the previous class
- A copy of Support Document 2
- Science notebook with table made in previous class

Procedure

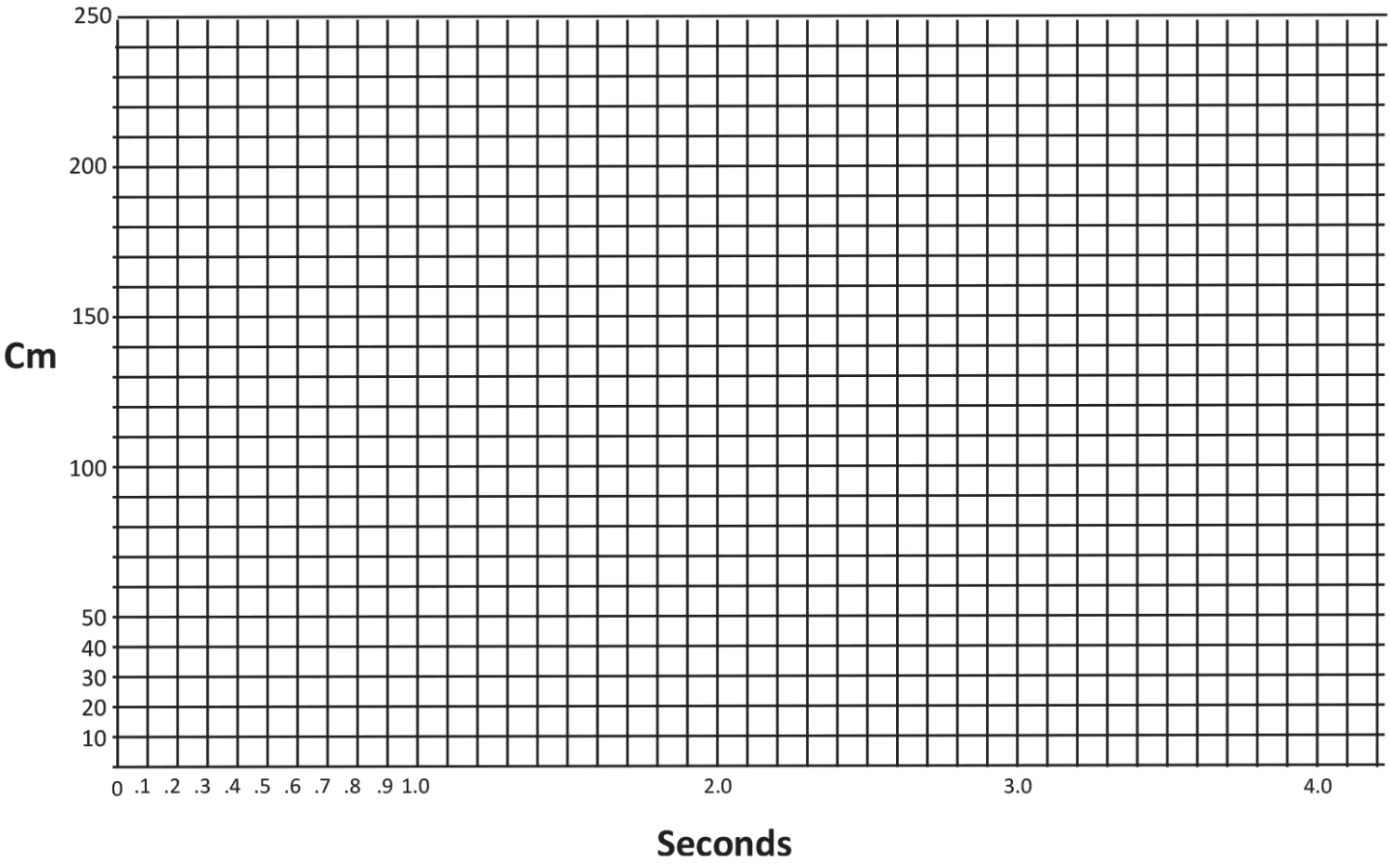
1. Ask students to look at their data table from the previous day. Ask them to find the half meter where the car was going fastest. **It is often the second or third half meter.** Ask the class to find the half meter where the car was going slowest using the data table. **It is usually the last half meter.**
2. Ask students to look at their graph for both of these half meters. What do they notice? **Where the car went faster, the slope is steeper. Where the car went slower, the slope is shallower.** In addition, also ask students to:
   - Calculate the average speed of the whole graph
   - Calculate the average speed of the fastest half meter
   - Calculate the average speed of the slowest half meter.
3. Go through the remaining half meters, comparing what they saw with the car, and what the graph looks like.
4. Ask students to predict (sketch in pencil on their graph from the previous day) what the graph might look like if the back wheels of the car were wound only 3 times with the rubber band. Label the sketch "3 turns." Ask them to do the same if the back wheels of the car were wound 5 times, and again sketch this. Label it "5 turns."
5. Divide the class in half, and ask half of the teams to repeat the previous day's activity with 3 turns, and the other half with 5 turns.
6. Hold a class discussion beginning with students' predictions, ending with the appearance of the graphs and what that meant about the overall motion of the cars.

   Students might or might not predict different slopes for different numbers of turns. However, overall, 3 turns has a shallower slope than 4 turns, and 5 turns has a steeper slope than 4 turns.
7. Project Support Document 3, 1 graph at a time. Ask students to use evidence from each graph to tell the story of the car's travel over time.
   - **In Graph 1 the car went a constant speed the whole time.**
   - **In Graph 2 the car sped up for awhile, then slowed down, then stopped (this is a good place to introduce the term "variable motion" from the NC Essential Science Standards).**
   - **In Graph 3 the car started out fast, but went slower and slower but continued to move.**
   - **In Graph 4 the car was moving at a constant speed, then bumped into something and went backwards, then stopped.**

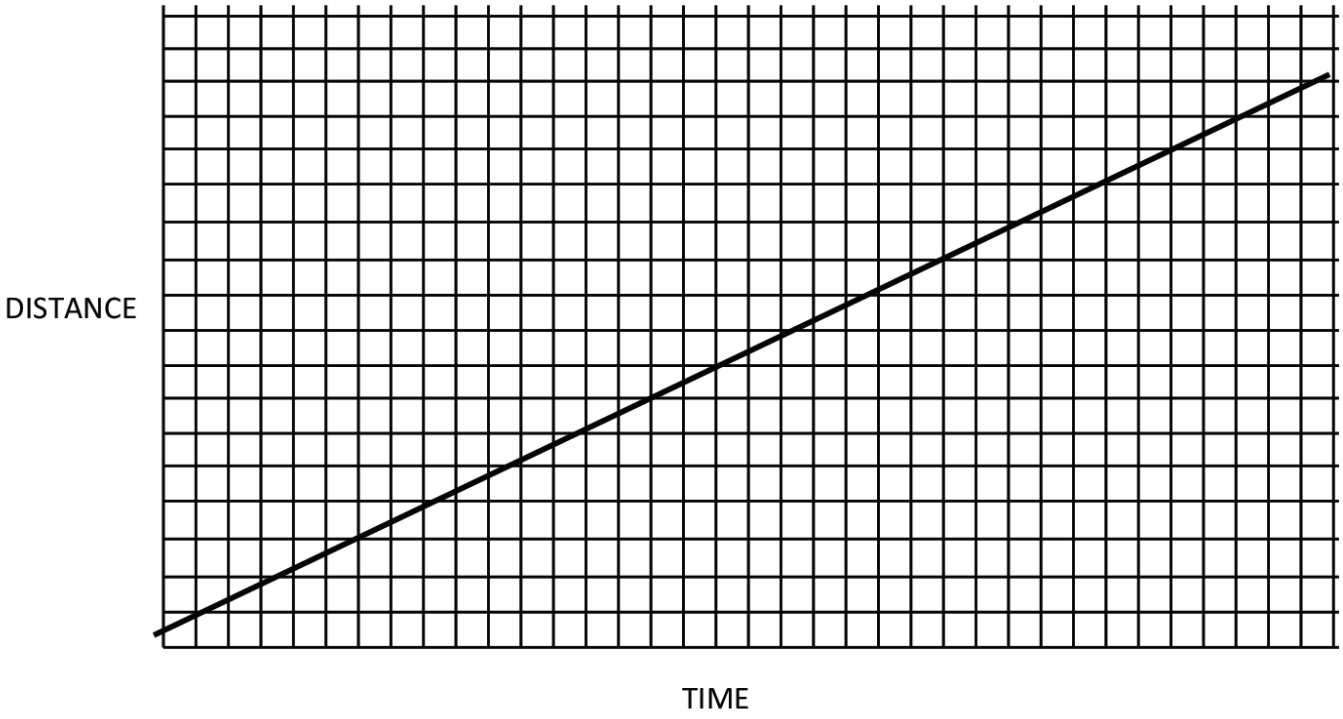
Time and Distance Data Table

	Number of winds of rubber band:_____				
TRIAL #	1	2	3	4	5
DISTANCE	TIME				
	sec.	sec.	sec.	sec.	sec.
50 cm					
100 cm					
150 cm					
200 cm					
250 cm					

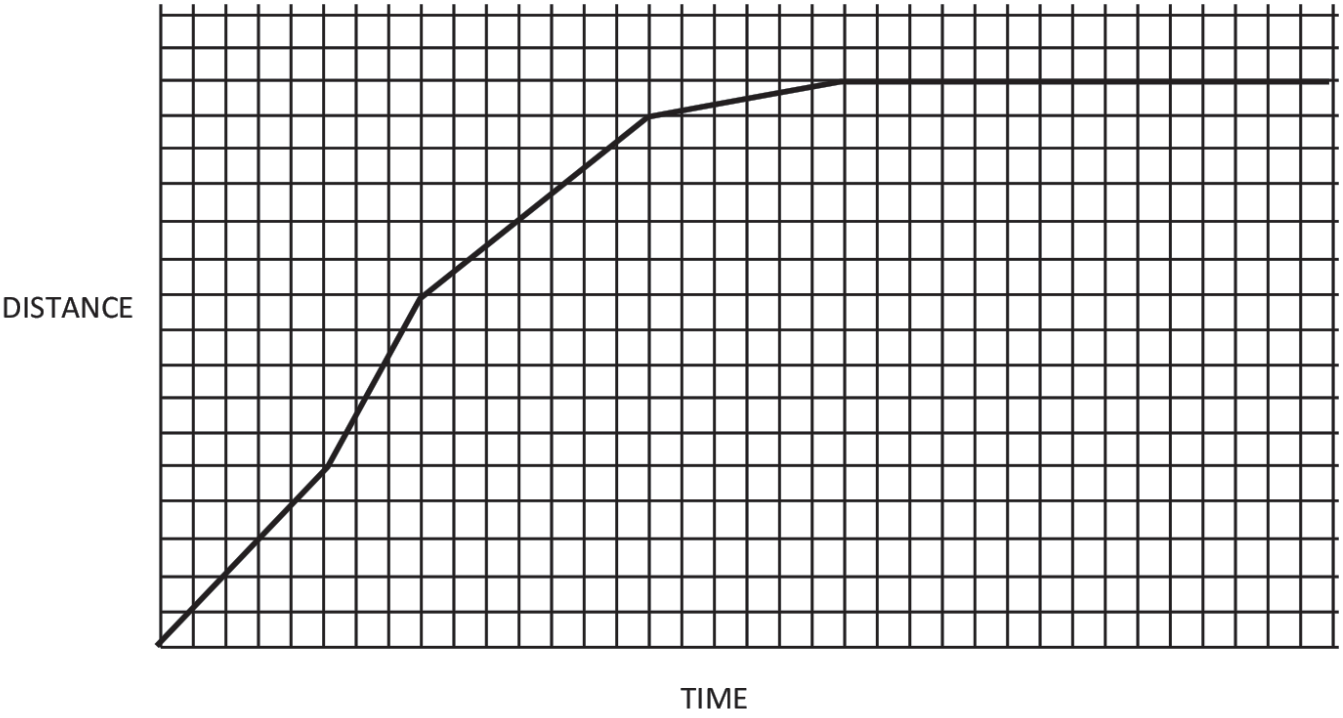
Time and Distance Graph



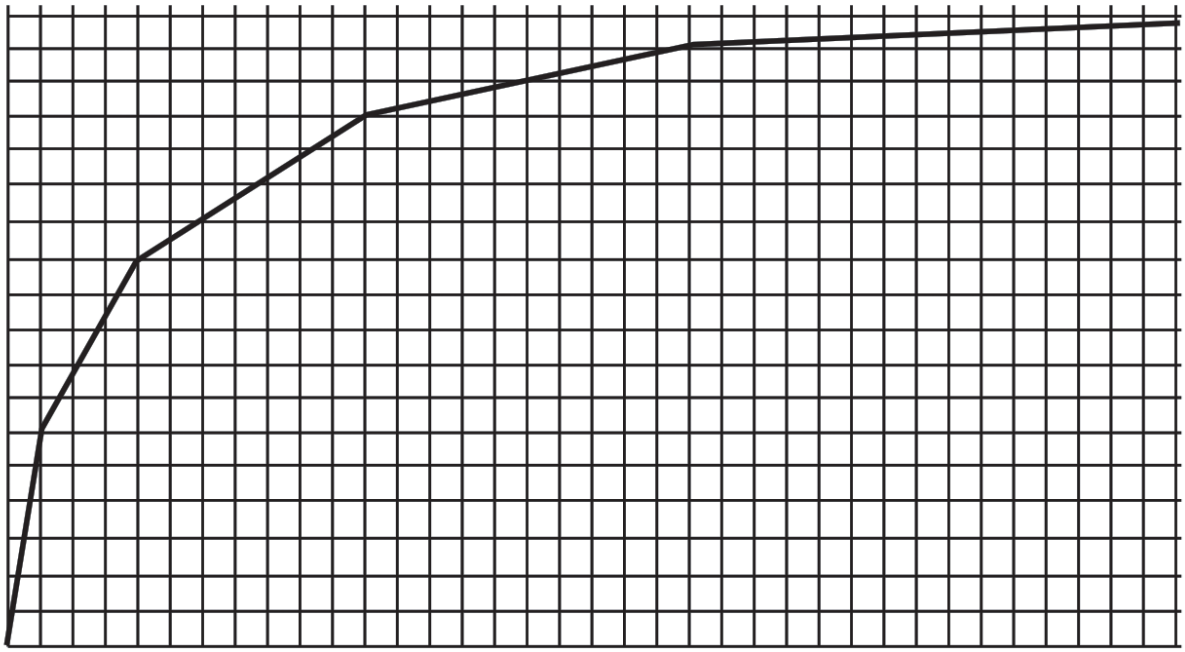
SAMPLE GRAPH 1



SAMPLE GRAPH 2



SAMPLE GRAPH 3



SAMPLE GRAPH 4