Throughout the guide teaching tips are in red.

Overview

These three activities introduce position, direction, and speed over 3-4 class periods. They follow information that NASA would need in order to hit an asteroid with a missile. The first activity asks students to match the speed of another team's vehicle released from a ramp. The second activity is about specifying a location with measurements so that another team can place an object in an exact position. The third activity asks students to use what they have learned to collide two cars rolled down two different ramps. To do this, they set direction of travel and make two vehicles cross a specified location at an exact time.

Objectives

- Students will describe an object's speed by distance traveled and time to travel that distance.
- Students will use measurements to determine position.
- Students will direct a moving object to cross a specified destination (determine direction).
- Students will use speed, time, distance, and direction to intercept a moving object.

NC Essential Science Standards

7.P.1.1 Explain how the motion of an object can be described by its position, direction of motion, and speed with respect to some other object.

Science Background for Teachers

Diverting an asteroid away from Earth would require NASA to do difficult calculations using powerful computers. However, this problem offers a framework for looking at basic components of motion: position, time, direction, and speed. These activities ask students to measure distance traveled, exact position, and the time a moving object takes to travel a specified distance.

Part 1 – Speed Match

Materials and Preparation

Materials for the whole class

- Projector and screen, computer, and internet access to project the video
http://newsfeed.time.com/2013/10/17/this-giant-astroid-could-hit-earth-within-20-years/
- A location and ramp materials to demonstrate the ramp setup for all to see (see Support Document 1).
- Support Document 2
- Masking tape

Materials for teams of three students

- Car

- Wooden ramp
- Ruler
- Medium sized binder clip
- Timer
- Tape measure
- Index card

Preparation

1. Be ready to project the video **http://newsfeed.time.com/2013/10/17/this-giant-astroid-could-hit-earth-within-20-years/**
2. Place a ramp, ruler, binder clip, masking tape, car, and measuring tape where you can demonstrate the setup for the class (see Support Document 1), including the tape at the base of the ramp. Practice the setup. The overhead view shows the car's back axle touching the edge of the ruler. This is always the start point for rolling the cars.
3. Clear space in the classroom for teams to set up ramps with about 8 feet of clear, flat, smooth uncarpeted floor surface ahead of the bottom of the ramp.
4. Be able to project Support Document 2.

Procedure

1. **Show the video** **http://newsfeed.time.com/2013/10/17/this-giant-astroid-could-hit-earth-within-20-years/** Afterward, explain that NASA might try to hit an incoming asteroid with a rocket in order to keep it from hitting Earth. Ask everyone to list in their notebooks as many things as they can think of that NASA would need to know to do this. After a few minutes, briefly discuss as a class to get a sense of students' ideas. Afterward, if no one has mentioned the speed of the asteroid or rocket, explain that we are going to explore speed.
2. **Demonstrate the ramp** with the binder clip, ruler, ramp, and car. Have Support Document 2 and the projector ready. Have a short tape strip on the rolling surface ready for the ramp.
   a. Place the low end of the ramp even with the edge of the tape. Make sure students see this.
   b. Show the ruler and clip. Show how to move the clip along the ruler and set the top of the clip on the ruler at 8 cm. Place the ruler and clip upright and rest the high end of the ramp on the wire binder clip handles. Read the ruler at the top edge of the clip and say that the ramp is 8 cm high. Project Support Document 2 and record 8 cm in the top row in the "height of ramp" column.
   c. Place the car at the top of the ramp with the back axle touching the edge of the ruler. Point the ramp so that the car rolls across a space you can measure. With timer in hand, release the car. Start the timer when the front wheels touch the floor. Let the car roll to a stop and stop the timer when the car stops. Read out the time to 0.01 seconds. Record the time in the "time of travel" column on Support Document 2, and project this as before.

d. Measure (and show how to) from the edge of the tape to the car's front wheels. Say the measurement aloud and record this distance at the top of the "distance traveled" column.

e. Explain that to fill in the "avg speed" column, we divide the "distance traveled" by the "time of travel" for that row. Do this, and record the number in "avg. speed." Point out the units: cm/sec. **This is a good time to define speed: the distance something travels in a certain amount of time. Mention that, in this case, we call it "average speed" because the car does not always travel at the same speed: it starts out fast and slows to a stop.**

3. Give a copy of Support Document 2 to each team. Explain that each team will do what you have just done, except that they will choose a ramp height between 4-20 cm and record these on the top half of Support Document 2. Other teams should not see their ramp height.

4. When they have chosen and recorded the ramp height, give out the remaining materials. Explain that each team will conduct and record 5 trials on the top half of Support Document 2, all at their chosen height. Let teams do the trials as you have shown. Be sure they always fill in all columns of Support Document 2. After cars are timed and distance measured, they should calculate and record average speeds. After a team has done 5 trials, ask them to circle the MEDIAN (middle value) average speed and write this number on an index card. At this point, ask them to take the ramps apart, and leave everything except Support Document 2 at their station. Remove binder clips from rulers.

5. Ask teams to find a team that did not see what they did and swap index cards containing their median average speed and go to the partner team's disassembled setup. Write the other team's average speed in the far right column of Support Document 2 under "SWAP AVERAGE SPEEDS." Their challenge is to set the ramp height so that the car goes the same speed from the bottom of the ramp to where it stops. They have 5 chances to find that height. Ask them to fill in the remainder of Support Document 2 with each attempt. When they get what they think was the original height, ask them to write this on the index card.

6. As each team finishes, ask them to return the index card with their ramp height determination to the team that gave it to them. They can then compare ramp heights using Support Document 2. Hold a brief class discussion about how this went.

7. Ask everyone to write a rule in their notebook that compares the height of the ramp to the car's avg. speed. **Sample rules might include: A higher ramp makes the car go faster and farther; a lower one makes the car go slower. You have to adjust the height of the ramp to make the car go a certain distance and speed.**

8. Ask everyone to write a rule in their notebooks that defines "speed" in their own words, using the terms "distance" and "time." **For example "how far something goes in a certain amount of time."**

9. Hold a brief class discussion to speculate how NASA might find out how fast an asteroid is approaching the earth.

Part 2 – Position

Materials and Preparation

Materials for the whole class

- 16 numbered position markers

Materials for pairs of students

- Tape measure
- An index card

Preparation

1. Place 16 (1 marker per pair of students in the class) numbered position markers at random spots on the floor around the room 4-5 feet away from each other.**2.**

Optional (not necessary but possibly helpful): photograph marker placements to confirm final outcomes.

Procedure

1. When students come in, point out markers on the floor around the room and ask them not to move them.
2. Explain that to hit an asteroid, NASA would shoot a rocket to a point in space where the asteroid will be at an exact moment. Ask the class: How would they determine a point in space? Ask for ideas from the class and accept all ideas.
3. The challenge is to determine exact positions of the markers on the floor. Form pairs of students, and give each pair an index card and tape measure. Ask each pair to choose a marker, go to it with their index card and tape measure, and leave it in place.
4. Ask teams to record the location of their marker on their index card so that someone else could use the information to place the marker exactly where it is now. The index card must only include measurements and words. **Tell students they cannot draw diagrams or maps on the index cards.** After the information and team names are on the card, they can pick up the marker, find another pair, and trade cards and markers with them. Ask them to use the other team's card to place the marker exactly where it was.
5. After all pairs re-place the marker, have them check the position with the pair that gave them the index card.
6. Hold a class discussion and ask:
   - What worked to help another team place the marker?
   - When it was difficult to re-place the marker, what would have helped to make it easier?
7. Optional, if necessary, repeat steps 2-4.
8. Hold a class discussion that touches on the following:

- How important is accuracy in measuring?
- What are important qualities of "landmarks?" **They should be fixed (if reference points move, a later measurement will not correctly place the marker). The point measured from needs to be clear and specific (e.g. not "the desk," but "the front left leg of the desk."**
- How many landmarks are needed? **In some cases, 2 measurements specify 2 different places, requiring a third landmark measurement to fix the point. 2 measurements from landmarks along a wall may converge at only one place in the room, but 2 measurements from landmarks in the middle of the floor might converge in 2 possible places in the room.**
- Hold a position marker at shoulder height and ask: If the marker was right here, what measurements would be needed to locate it? **A measurement of height above the floor would be needed. If appropriate, as a relevant application of this, explain that cell phone GPS uses measurements from 3 satellites or cell towers to determine location. Similarly, NASA would use multiple radars to locate an incoming asteroid.**

Part 3 – Collision

Materials and Preparation

Materials for the whole class

- Support Document 3
- A roll of masking tape
- A marker to write on the tape

Materials for groups of 6 of students (2 teams of 3)

- 2 ramp boards
- 2 rulers
- 2 medium binder clips
- 2 cars
- 2 tape measures
- 2 timers

Preparation

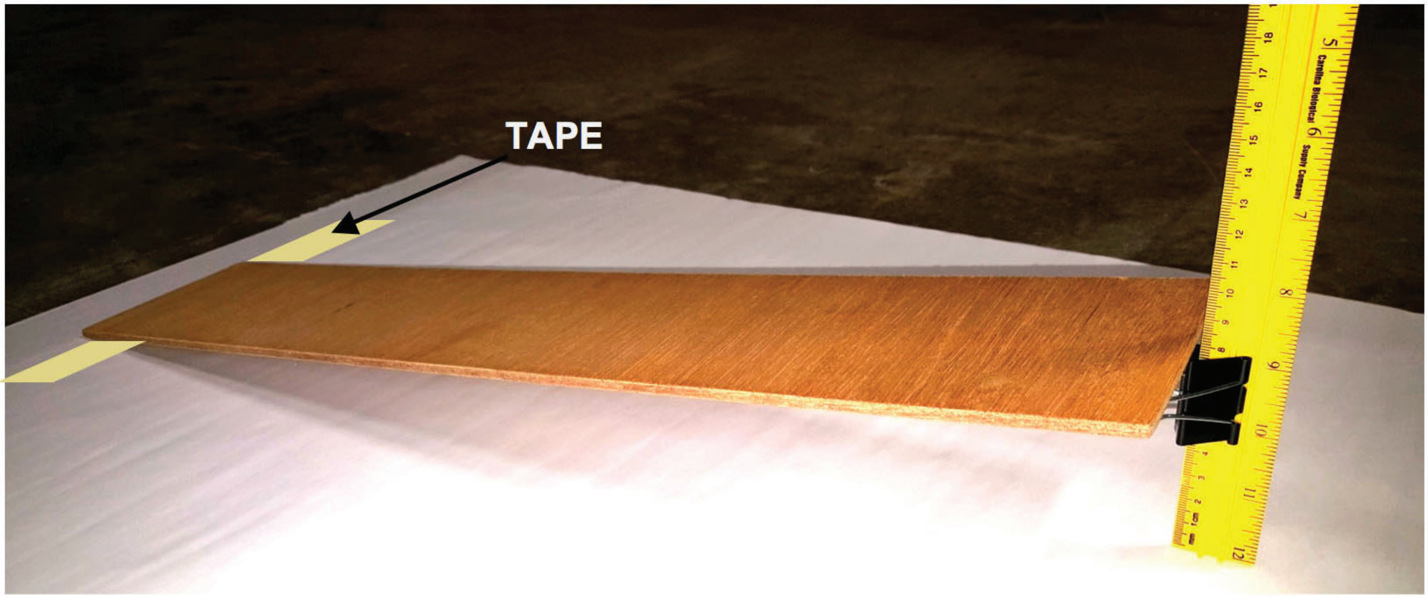
1. Set up ramps on a clear, flat, smooth uncarpeted floor surface.
2. Place triangles of tape (collision stations) on the floor around the room, one triangle per 6 students (2 teams of 3), as shown in "first collision setup" on Support Document 3 (rough measurements OK). Set the asteroid and missile tapes perpendicular to a line drawn directly to the small square of tape ("impact point.") With a marker, label:
   - Small tape - "impact point"

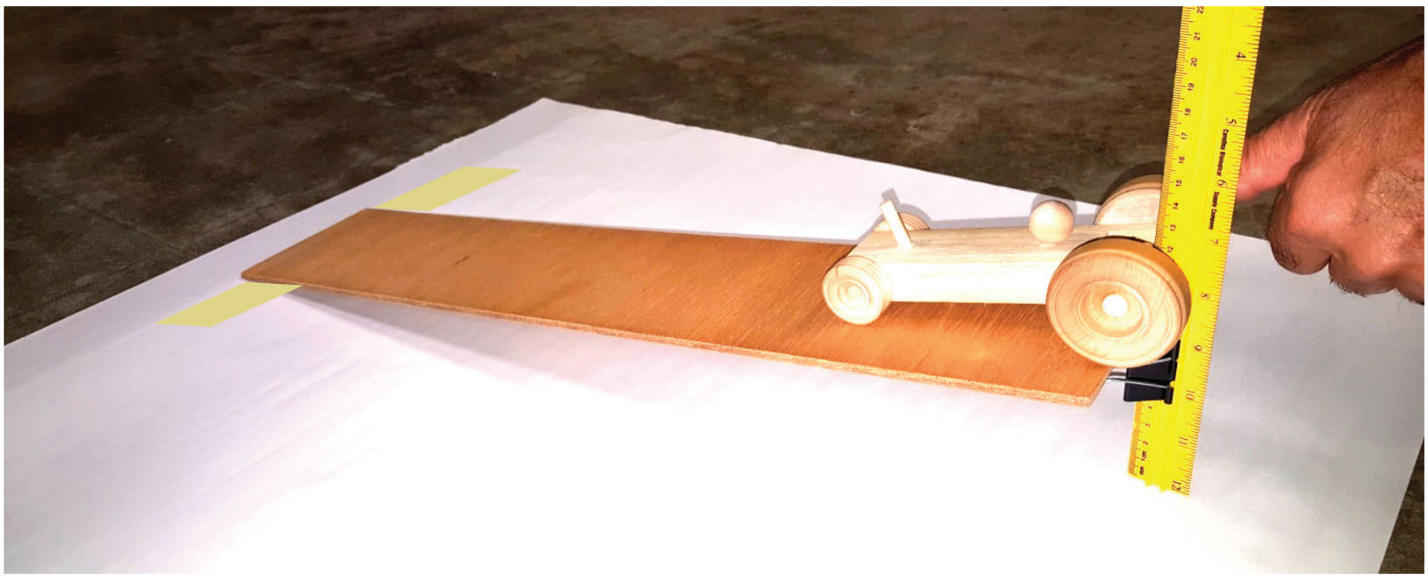
- tape nearest impact point - “missile”
- tape farthest from impact point - “asteroid”

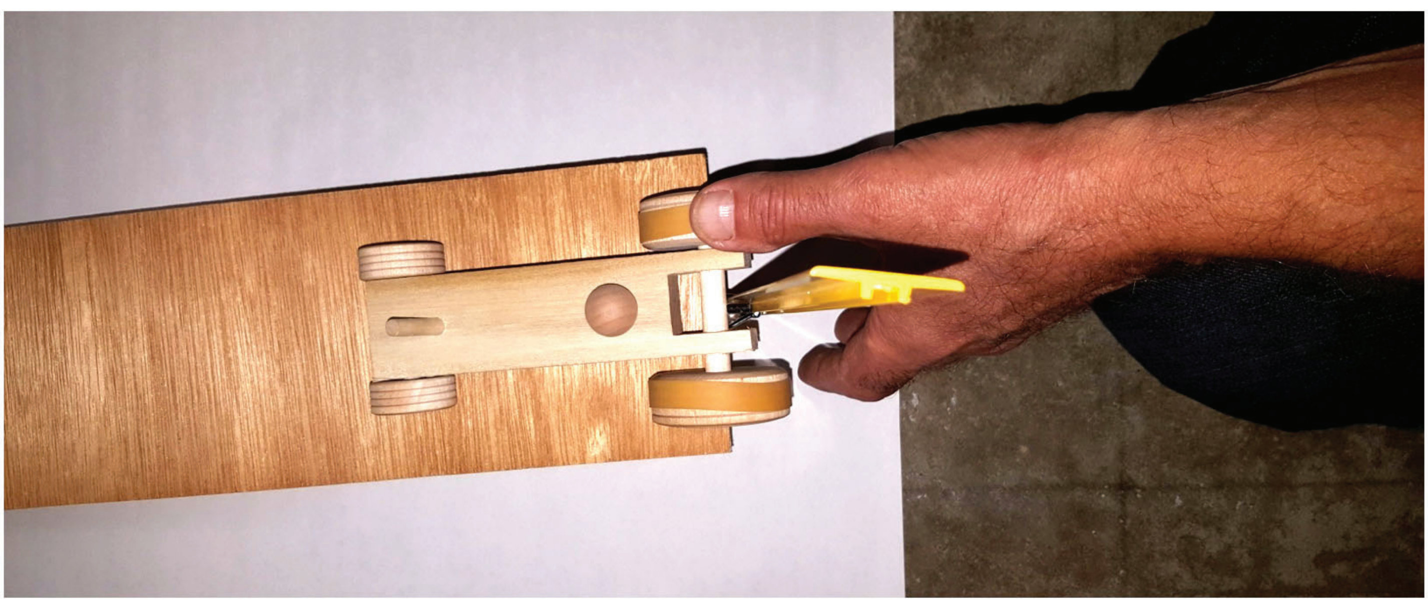
Procedure (15 minutes)

1. Form 2 teams of 3 and give out materials. Ask teams to choose a collision station and take their materials to it. Explain that the challenge will be to use what you have learned about speed, distance, and time to collide the two cars at the impact point on the first try. At first, they will have time to do “research and development (R&D).” During this phase, ONLY ONE CAR CAN BE IN MOTION AT A TIME.
2. One team will be the asteroid, and one team will be the missile. Ask the asteroid team to set their ramp height at 25 cm with the binder clip (as in previous activity). Place the bottom of the ramp on the edge of the “asteroid” tape nearest pointing toward the impact point. Ask all of the asteroid teams to roll their cars and time them **from the moment they are released at the top of the ramp** until they reach the impact point. **Be sure students begin timing when they release the car.** Cars must be released with back axle touching the ruler (bottom photo Support Document 1). Ask them to repeat several times until they record their most accurate time. After this, the asteroid team will NOT roll their cars until both teams try the collision. **In addition to providing an accurate time, the asteroid will need to ensure their car crosses over the impact point. This will require the team to position the ramp correctly. The car may not run perfectly straight; therefore trial and error will be required to ensure it crosses the impact point.**
3. During this R&D phase, the asteroid car can no longer be rolled (only one car in motion at a time). However, the teams can roll the missile car to practice and get ready. They have one important piece of information: how long it takes for the asteroid to reach the impact point. Now, they have to figure out how to hit it on the first try. They have 10 minutes of R&D time.
4. Stop the class after 10 minutes. Allow each group to attempt the collision, and the rest of the class to watch. At this point TWO CARS CAN BE IN MOTION AT A TIME. They get only one try. **If you prefer, you can allow groups that are unsuccessful to have one more try.**
5. Reverse the 3-person groups within the teams so that the asteroid group is now the missile group, and vice-versa. Re-place the tapes as shown in “second collision setup” on Support Document 3. This moves the asteroid tape a foot closer to the impact point and lowers the asteroid ramp height to 20 cm. Repeat steps 2-4, as before, first timing the “asteroid” car, then letting the “missile” group do R&D, and finally coordinating for the collision. **As before, if you prefer, you can allow unsuccessful groups to have another try.**
6. Hold a class discussion to list everything that students did in order to crash the two cars at the impact point. Discuss how each of the following were essential to solving the problem:
   - Position
   - Direction of motion
   - Speed

Support Document 1







Support Document 2

Names: ______________________________

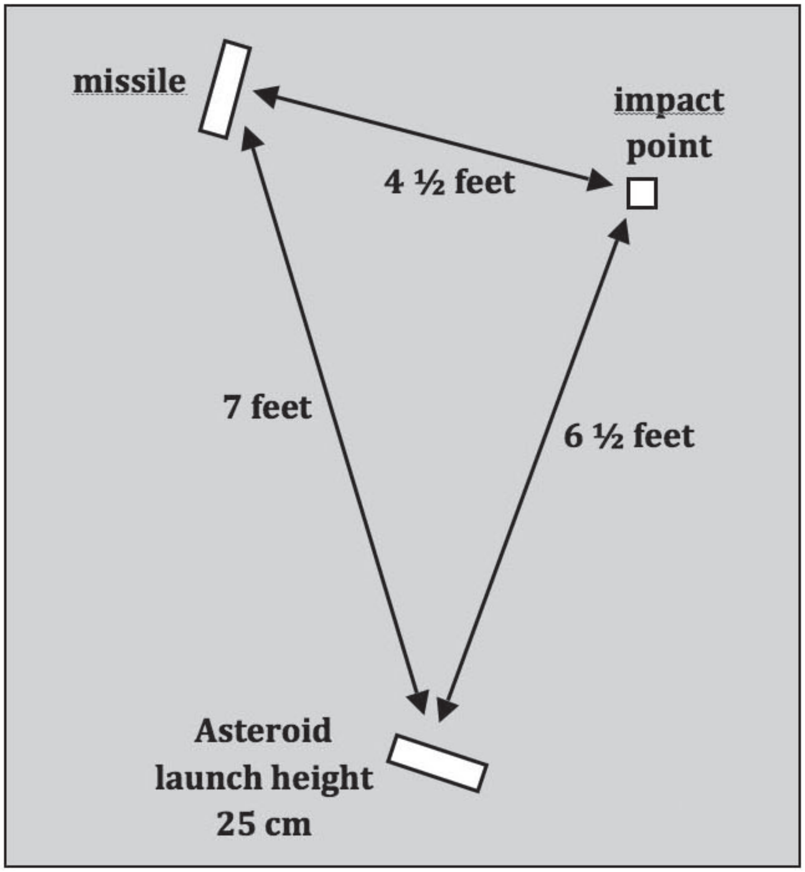
Height of Ramp	Distance Traveled	Time of Travel	Avg. Speed
			cm/sec
			cm/sec
			cm/sec
			cm/sec
			cm/sec

⇓ SWAP AVERAGE SPEEDS ⇓

Height of Ramp	Distance Traveled	Time of Travel	Our Avg. Speed	Other Team's Avg. Speed
				cm/sec

Support Document 3

First collision station setup



Second collision station setup