

Vector Motion

Teacher's Guide

1.0 Summary

Vector Motion is the second activity in Dynamica and should be done after Vector Treasure Hunt. This activity should take students approximately 45 minutes to complete.

2.0 Learning Goals

Driving Question: How is motion described?

This activity introduces students to the concept of rate of displacement over time (velocity) by manipulating the motion of various objects. Students resolve velocity components by using the diagonal method and compare the relationship between displacement and velocity - time graphs for a specified motion.

Step One: In **Racing a Car**, students are challenged to move a car over a straight track in a given time.

Step Two: In **Rounding Curves**, students develop an understanding of motion by maneuvering a car around a track by manipulating its velocity (speed and direction).

Step Three: In **Racing with Boosters**, students use velocity boosters to round a track.

Step Four: In **Skateboarding Over a Target**, students hit a target by designating horizontal component of a velocity vectors.

Step Five: In **Skateboarding Over a Timed Target**, students hit a target by designating horizontal component of a velocity vectors in a certain amount of time.

Step Six: In **Skateboarding Over a Timed Target in 2D**, students use both horizontal and vertical components of velocity vectors to hit a target in a certain amount of time

Learning Goals

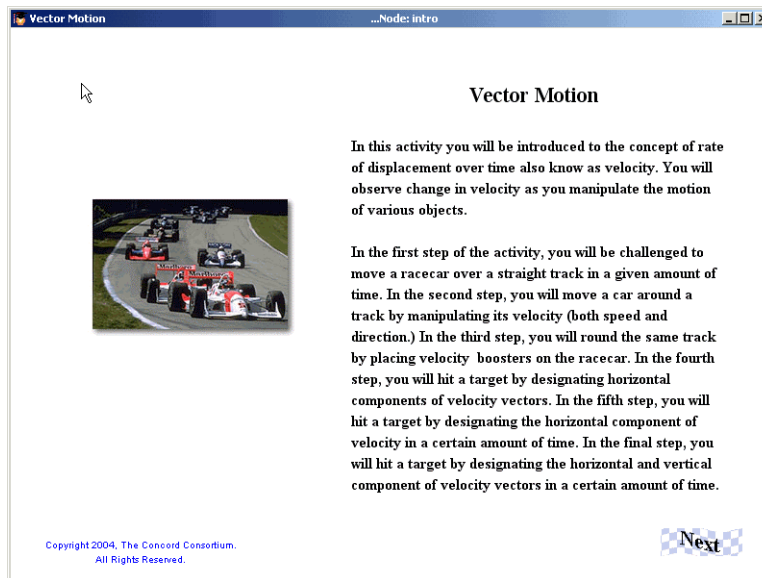
- Students will develop an understanding of motion, speed and direction.
- Students will manipulate the horizontal component of velocity vectors.
- Students will manipulate the vertical component of velocity vectors.
- Students will understand resultant velocity vectors.

Additional Teacher Background

The motion of an object is where it is, how fast it's moving, and in what direction - that is, its position and its velocity. Just a scalar distance and displacement have different meanings, speed and velocity are not the same. Speed is how fast you are going (change in distance / change in time), regardless of your direction. The speedometer of a car measures speed.

Velocity (a vector), however, has two parts: speed and direction. Driving north at 30km/hr is a velocity and is different from driving east at 30km/hr.

In Vector Treasure Hunt, students added vectors together in a tip to tail method to determine displacement. The order of the addition did not matter. While dealing with velocity vectors, the overall motion is shown by the resultant of the total displacement over a specified time. Each horizontal and vertical component of the motion can be displayed geometrically by creating the sides of a parallelogram. The resultant of the motion is shown as the diagonal of the parallelogram.



Opening screen

3.0 Standards Alignment

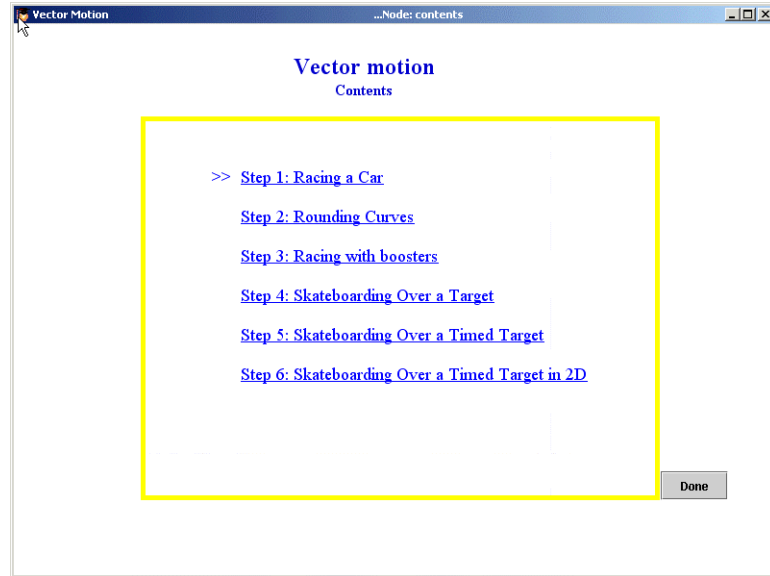
Alignment to National Math and Science Standards (NCTM or NSES)

Objective	Standards
<p>Students will describe the properties of vectors.</p>	<ul style="list-style-type: none"> • Students should understand vectors as systems that have some of the properties of the real-number system. • Students should understand meanings of operations and how they relate to one another. • Students should understand that vectors are composed of both magnitude and direction.
<p>Students will manipulate a velocity vector to control motion.</p>	<ul style="list-style-type: none"> • Students should use dynamic geometrical representation to develop an understanding of vectors. • Students should manipulate a velocity vector to control movement.
<p>Students will observe and describe rate of change over time.</p>	<ul style="list-style-type: none"> • Students should analyze functions of one variable by investigating rates of change. • Students should approximate and interpret rates of change from graphical and numerical data.
<p>Students will use vector representations to explain phenomena.</p>	<ul style="list-style-type: none"> • Students should use dynamic geometrical representation to develop an understanding of vectors. • Students should understand ways of representing numbers and relationships among numbers. • Students should use representations to model and interpret physical and mathematical phenomena. • Students should use mathematical models to represent and understand quantitative relationships. • Students should understand relations and functions and select, convert flexibly among, and use various representations for them. • Students should manipulate a velocity vector to control movement. • Students should use mathematical models to represent and understand quantitative relationships.
<p>Students will add vectors.</p>	<ul style="list-style-type: none"> • Students should recognize and apply mathematics in context outside of mathematics. • Students should identify essential quantitative relationships in a situation and determine the class or classes of functions that might model the relationships. • Students should generalize patterns using explicitly defined and recursively defined functions. • Students should understand meanings of operations and how they relate to one another. • Students should understand relations and functions and select, convert flexibly among, and use various representations for them. • Students should apply and adapt a variety of appropriate strategies to solve problems.

4.0 Activity Sections

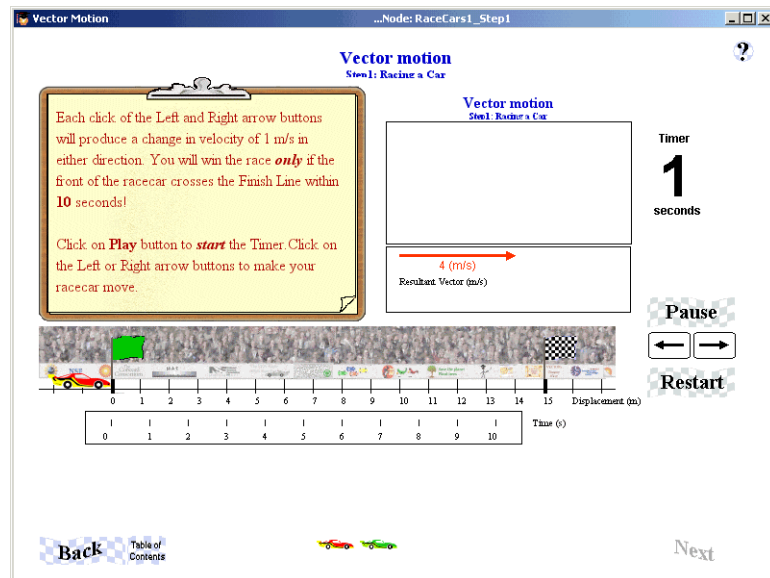
4.1 Table of Contents

This activity has 6 steps. Steps should be done in order.



4.2 Step 1: Racing a Car

This is the introductory section to the Vector Motion activity. Student uses the arrow keys to add velocity to the car. Students use the time graph to relate displacement and time and, finally, velocity. They are also introduced to motion graphs.



Students use keyboard to add velocity to the car

Vector Motion

Vector motion

Step 1: Racine a Car

Again you will have **10 seconds** to cross the Finish Line.

But, this time you must cross it moving at exactly **6 m/s**.

Click on **Play** to start the timer. Use the Left and Right arrow button again to move your racecar.

Displacement (m)

Time (s)

Velocity (m/s)

Time (s)

Displacement (m)

Time (s)

Timer

7 seconds

Pause

Restart

Back

Table of Contents

Hint

Next

Student is given the goal to reach the finish line at a velocity of 6m/s

Vector Motion

Vector motion

Step 1: Racine a Car

Observe the displacement versus time and the velocity versus time graphs of the motion of your racecar.

Answer the question below.

Click on the **Next** button when finished.

Displacement (m)

Time (s)

Velocity (m/s)

Time (s)

Displacement (m)

Time (s)

Timer

5 seconds

Play

Restart

4. Describe the motion of your racecar by observing the displacement and velocity graphs.

Back

Table of Contents

Next

Student is introduced to motion graphs

4.3 Step 2: Rounding Curves

In this section, students will use velocity vectors to round curves. There are sound effects in this activity—you may or may not choose to have students turn up the volume on their computers.

Hint: If students have trouble getting to the finish line without crashing, suggest that they slow the car down when going around the curve!

Vector motion
Step 2: Rounding Curves

Each click of the Left, Right, Up and Down arrow buttons will produce a change in velocity of 1 m/s in either direction. Try to reach the Finish Line without hitting a wall.

Click on the **Play** button to start the Timer. Click on the Left, Right, Up or Down arrow buttons to make your racecar move.

Timer
13
seconds

Previous velocity vector (1, 1)
New Velocity vector (0, -1)
Resultant velocity vector (1, 0)

Pause
Restart

Back Table of Contents Next

Students use velocity vectors to round curves

Vector motion
Step 2: Rounding Curves

Now the practice runs are over! This time you will complete a lap around the racetrack.

You can click on the **Pause** button while the car is moving if you need time to think.

Click on the **Play** button to start the Timer. Click on the Left, Right, Up or Down arrow buttons to make your racecar move.

Timer
4
seconds

Previous velocity vector (1, 0)
New Velocity vector (1, 0)
Resultant velocity vector (2, 0)

Pause
Restart

Back Table of Contents Hint Next

Students must drive the entire track

4.4 Step 3: Racing with Boosters

Step 3 introduces students to boosters that increase a car's velocity. When the car hits the dot on the booster, its velocity increases or decreases by the number on the booster. So, a booster of -1 would decrease the car's velocity by 1m/s .

Vector motion
Step 3: Racing with boosters

Great! You win the race.
Click on the Next button to continue.

Timer
6
seconds

Previous velocity vector $(3, 0)$
New velocity vector $(-1, 0)$
Resultant velocity vector $(2, 0)$

Back Table of Contents Hint Next Pause Restart

Student must add a booster to start the car, and then add one to slow it down to reach the goal of 2m/s

Vector motion
Step 3: Racing with boosters

Try again!
After typing the velocity values, click on the Play button to start the Timer.

Timer
6
seconds

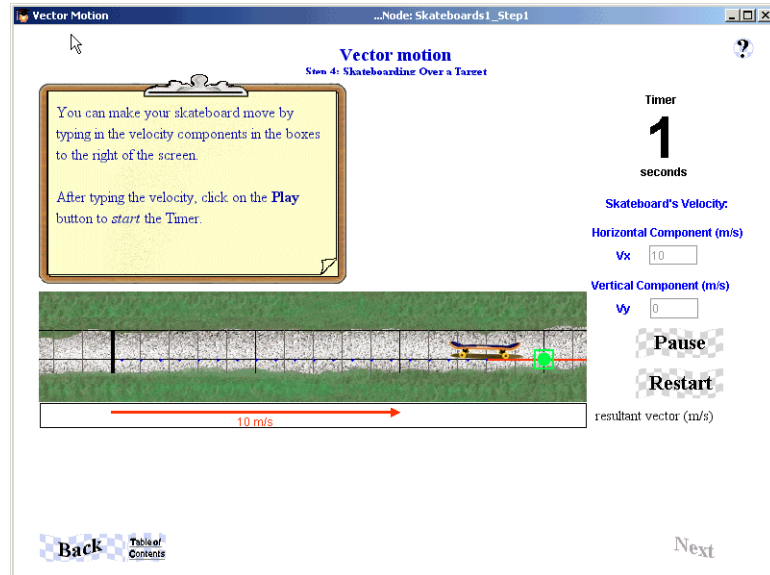
Previous velocity vector $(1, 0)$
New velocity vector $(0, 1)$
Resultant velocity vector $(1, 1)$

Back Table of Contents Hint Next Pause Restart

Student adds velocity boosters to the car to turn the corner

4.5 Step 4: Skateboarding Over a Target

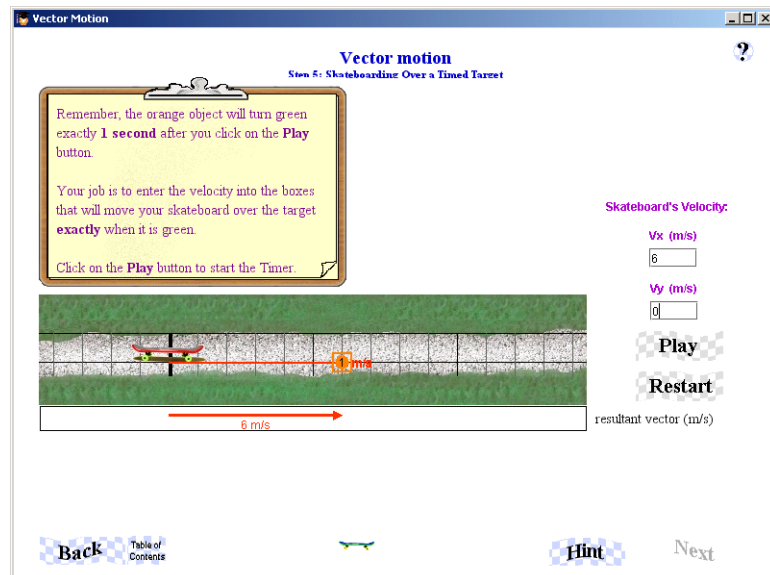
This section introduces students to velocity vectors in the x and y direction. The student must choose an x and y velocity to send the skateboard over the target.



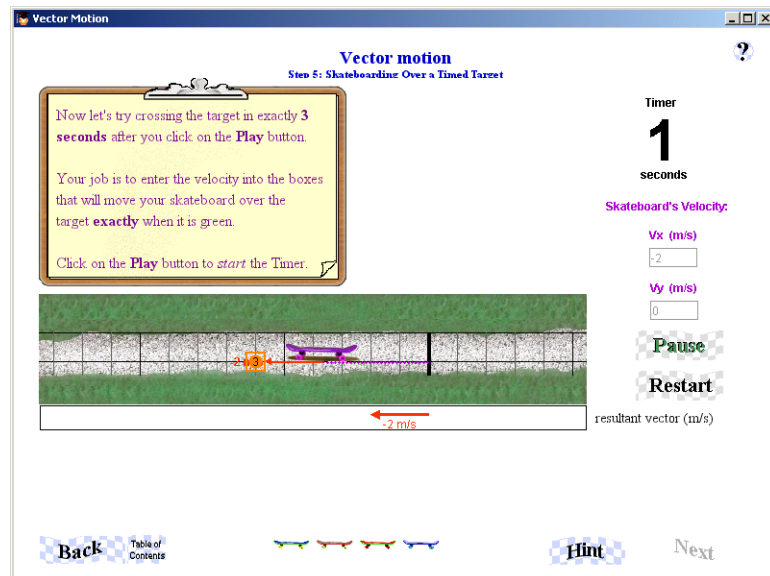
Vx vs. Vy

4.6 Step 5: Skateboarding Over a Timed Target

In this activity, students will select velocities based on the amount of distance that needs to be traveled in a certain amount of time. The squares on the grid each represent 1 meter. To move the skateboard to the left, the velocity must be negative.



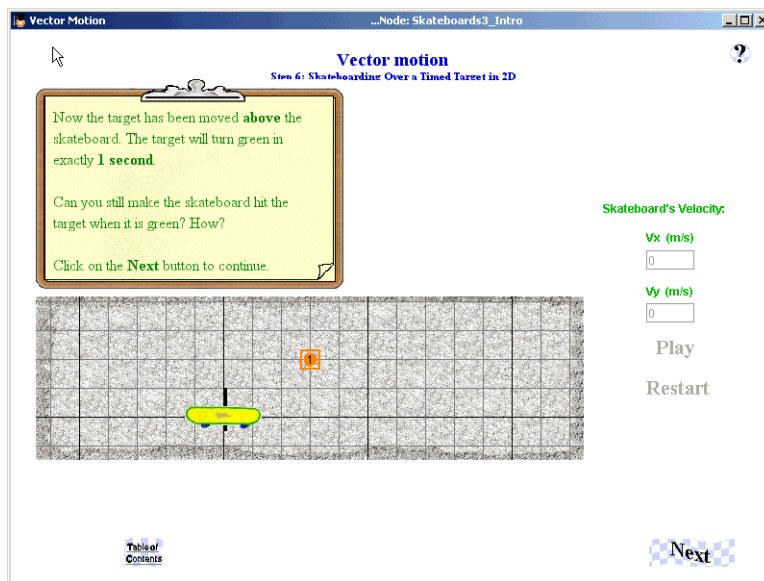
Students relate distance and time required to calculate velocity



A clock timer is used to help the student keep track of seconds

4.7 Step 6: Skateboarding Over a Timed Target in 2D

Students can now select velocities in both the x and y directions. Students should use the grid (again, one square equals one meter) to calculate the magnitude and direction of the velocity vectors.



2D grid with orange target

After students answer a few questions about how to solve this problem, they will be asked to fill in values for the velocity vectors. In the next screen, the values that they choose for V_x and V_y are also represented visually on the grid above the model.

Vector Motion ...Node: Skateboards3_Step1

Vector motion
Step 6: Skateboarding Over a Timed Target in 2D

Remember, the target will turn green in exactly **1 second**. Your job is to enter the velocity component(s) that will move your skateboard over the target exactly when it is green.

After typing the velocity values, click on the **Play** button to *start* the Timer.

Skateboard's Velocity:

Vx (m/s)
3

Vy (m/s)
2

Play

Restart

Back Table of Contents Hint Next

Notice the velocity vectors that indicate a velocity in the x and y directions

Vector Motion ...Node: Skateboards3_Step2

Vector motion
Step 6: Skateboarding Over a Timed Target in 2D

Now try hitting the next target below the skateboard. The target will turn green in exactly **1 second**. Your job is to enter the velocity component(s) that will move your skateboard over the target exactly when it is green.

After typing the velocity values, click on the **Play** button to *start* the Timer.

Timer
0
seconds

Skateboard's Velocity:

Vx (m/s)
-5

Vy (m/s)
-3

Pause

Restart

Back Table of Contents Hint Next

Students are asked to solve problems using negative velocities

5.0 Student Reports

Your students' work in Vector Motion is logged and viewable on the MAC Project Web Portal at <http://mac.concord.org>. For each student, you can view a report containing questions and student answers. There is no final assessment or quiz in this activity. The next activity that students should use is Motion Graphs.