# TAP 201- 1: Adding velocities

Velocities obey the vector addition law.

You will have seen many examples of vector addition by now. This activity is designed to show clearly that velocities follow vector addition laws. This law is sometimes referred to as geometric addition, in contrast to the arithmetic addition law you are familiar with.

## You will need

- ✓ three dynamics trolleys
- ✓ a small plank of wood or trolley runway, perhaps 1.25 m long
- ✓ A3 drawing paper, pins and a drawing board
- ✓ ink water, plastic syringe, tubing and Blue-tack
- ✓ ruler and protractor

## Obtaining a resultant velocity
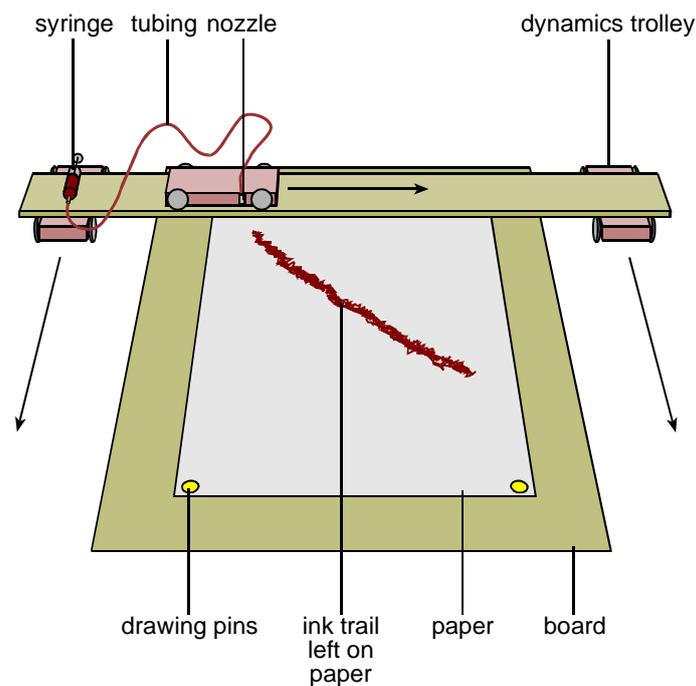


Two dynamics trolleys have a bridge connected between them. The third trolley has a syringe filled with ink water and a length of suitable tubing connected to it with Blue-tack. A piece of drawing paper is placed beneath the apparatus as shown.

You need to work in pairs for this activity. One member of the team will push the connected trolleys along the bench or floor at a constant velocity. Some practice will be needed to achieve this. This velocity can be measured.

The other team member must produce a constant velocity along the runway. The two velocities must be produced simultaneously when results are being taken.

When you think you can work together to produce constant velocities, use the syringe to leave an ink-water trail as you move all the trolleys together. Experiment with different velocities and try to explain qualitatively the shape of the trails you record.

If you measure the velocities you are producing the trail can be used to check the vector law of addition.

On one of your ink-trail pictures, add calculations and diagrams – using Pythagoras' theorem and/or trigonometry – to show how the measured velocities of the trolleys lead to the resultant motion recorded by the ink trails. Your final product should be suitable for display on the laboratory wall.

## Interpretation

1.     If you have measured the velocities of the trolleys then measuring the angle of the trail will allow you to cross check how well they fit the law of vector addition.

2.     You should be able to verify that velocities obey the vector law of addition.

3.     You might like to experiment with giving the trolley on the bridge a constant acceleration. This could be done using an incline. What shape of trail would you predict now?

## Practical advice

This activity is suitable for all abilities. The average student will enjoy showing a familiar law at work. Using the apparatus to produce sensible results will pose an interesting challenge to all students. Faster pupils might enjoy looking at paths produced when the bridge trolley accelerates as it moves forwards at a uniform velocity. This is good preparation for chapter 9. Of course this activity could be presented to the group as a demonstration with the teacher enlisting help from the students.

Qualitatively students should be able to account for the shape of the ink trail. Quantitative results are possible with care. There is opportunity to get students to use trigonometry to verify from the component velocities the angle of the ink trail on the paper.

Syringes and tubing are available from Phillip Harris and the bridge can be any suitable piece of wood. Here is a good use for old wooden dynamics trolleys!

## Alternative approaches

It may be easier to achieve a constant velocity for the two trolleys by using a Meccano crank with a long extension and two strings (one for each trolley). As the crank is turned steadily the trolleys advance at constant velocity.

The alternative to the above is the experiment using a motor to tow a cloth across the floor as a trolley moves across it. This idea was first introduced in Physics for the Enquiring Mind by Eric Rogers (Princeton University Press). We found his experiment difficult to get quantitative results from. However, it can be used to add vectors that are not at right angles.

## External references
This activity is taken from Advancing Physics Chapter 8, 210P