http://www.schoolsobservatory.org.uk/astro/cosmos/uniball

Expanding Universe Experiment

To understand how the redshift of galaxies is due to the expansion of the Universe, try the following experiment.

You will need the following items:

1. A round balloon (do not use a long, thin one).
2. Some coloured stick-on dots (at least 5 different colours).
3. A piece of string about 50cm long.
4. A ruler.
5. A stopwatch or other timer.

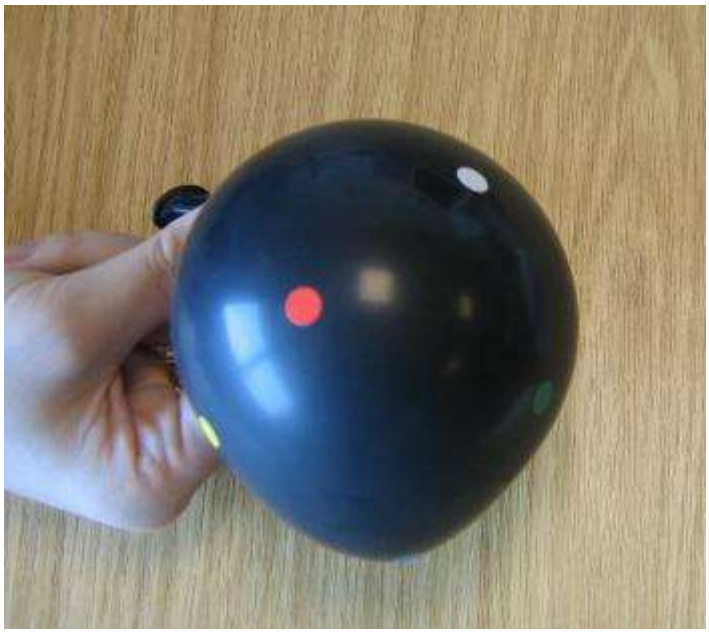
Step 1 : Setting Up

You will need to work in teams of at least two, one to blow up and hold the balloon and the other to make the measurements.

Before you start, draw a table for your results like the one below with the colours of your five dots in the 1st column:

Colour of Dot	First Distance *D1* in cm	Second Distance *D2* in cm	Change in Distance *D2 - D1* in cm	Speed *V* in cm/second
Red				
Green				
Blue				
White				
Yellow				
Time to fully inflate the balloon: seconds.				

Step 2 : Making the Measurements



Putting dots on the small balloon

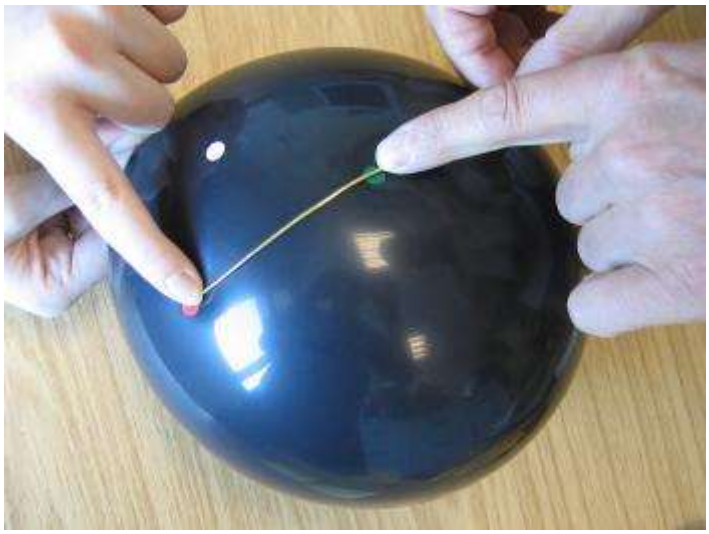
Blow up the balloon *a little bit* and hold the "nozzle" closed, but do not tie it up.

Stick your five dots onto the balloon. Try to spread them out over the whole balloon.

Each of the dots represents a whole galaxy, with the surface of the balloon being the Universe that they exist in.

Choose one of the dots to be your "home". You can choose any of them.

Step 3



Use string to measure the distance between two dots

While one of you holds the balloon, the other one can use the string to measure the distance from your "home" dot to one of the other dots.

Now measure the string distance with a ruler.

When you have measured the distance, write it down in your table in the *D1* column.

Step 4

Measure the distances from the "home" dot to all the other dots as well and fill in that column of the table.

Note: The distance from your "home" dot to itself is zero.

Step 5

Now carefully blow the balloon right up, using the stopwatch to time how long it takes. Write down the time in seconds.

Step 6

Now re-measure all the distances from "home" to all the other dots and write then down in the *D2* column of your table. Don't forget that the distance from your "home" dot to itself is zero.

You now need to work out the speed of each galaxy. Remember that:

Here, the **Distance travelled** is the difference between *D1* and *D2*, so calculate *D2* - *D1* for each of our dots and write them in the 4th column on the table.

Step 7

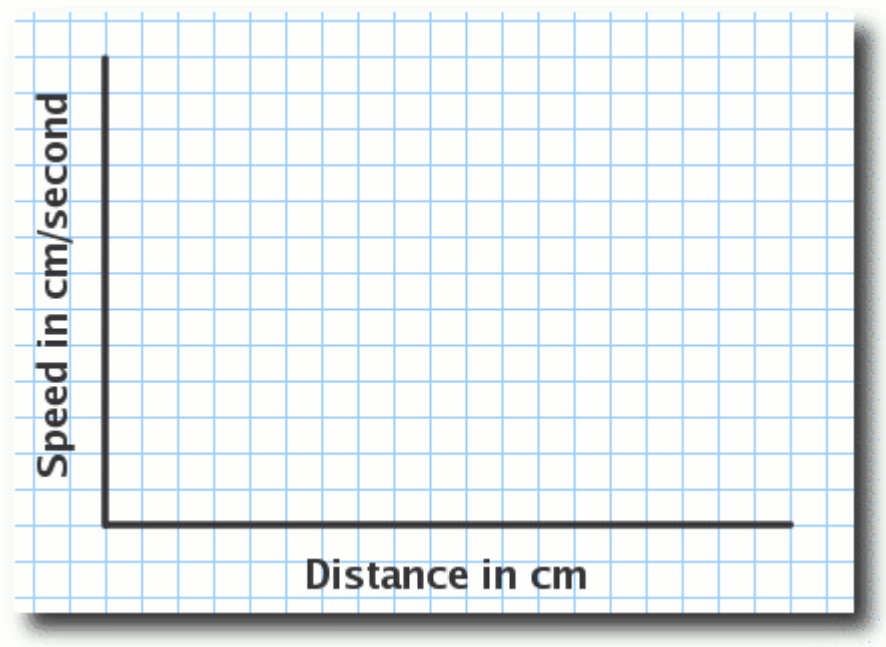
The **Time taken** is the time to blow the balloon up. Work out the speed *V* for each dot and put it into the 5th column. Because your "home" dot has not moved, its speed will be zero.

Step 8

We are studying how the **speed** that galaxies seem to have gets larger for galaxies that are further away.

The best way to see this is to plot a graph showing the **distance** along the bottom axis and with the **speed** up the side.

This means that you need to plot a graph with axes like the one below:



Put the points for all your dots on the graph using *D2* as the Distance.

Step 9 : What does it all mean ?

Use the ruler to draw a straight line that goes as close to as many of the points as possible (don't forget the "home" dot!)

Think about the following questions and discuss them:

- **Are the speeds of all the dots the same?**
- **If not, do they get faster or slower as they get further from the "home"?**
- **What would be different if you had chosen a different "home"?**
- **What would have been the same?**
- **What do you think this tells you about the way that the Universe expands and the redshift of galaxies?**

If you are not sure about some of the questions, can you think of a way changing the experiment to make them easier to answer?