Accelerating Matter

Summary

This activity uses magnetic force to accelerate a ball bearing. While it is not precisely the method that CLS uses to accelerate the electrons to produce synchrotron light, parallels can be drawn to help demonstrate similar concepts.

Pan-Canadian Objectives

Science Grade	Knowledge	Science, technology, society and the environment	Skills	ATTITUDES
10-12	325-1, 325-8, 326-3, 326-4, 328-1	116-3, 116-6, 116-7	212-4, 212-5, 212-6, 212-7, 213-2, 213-8, 215-1	439, 440, 441, 442, 443, 445
7-9	309-1, 309-2	112-4	208-5	422, 425, 430, 431

Materials

- Wooden or plastic ruler (not metal) with a groove down the length of it to 'guide' the ball bearings
- 3 or 4 magnets: Any magnet should work but the stronger the magnet the better. We used 'rare earth magnets'
- 7 or 9 metal balls (2 balls for each magnet plus one). For a very strong accelerator, try to use balls roughly the same size as the magnet. We used much larger ball bearings that were readily available from the shop and because we didn't want the last ball to move with much force for demonstration purposes
- Something to 'fix' the magnets to the ruler. We used sticky tack (note that we had to make sure that there was no sticky tack in front of the magnet), but tape could work too depending on the size and shape of the magnets

Background

When the starting ball begins to move towards the magnets, it is attracted by the magnetic force. It is thus accelerated and hits the first magnet at a certain velocity (v_1). During this impact, the ball immediately after the magnet remains at rest and conservation of momentum forces the next ball into motion at velocity (v_1) which is then attracted by the second magnet's force field and accelerated more. It hits the second magnet at velocity ($v_2 = v_1 + v_1$) and the process is repeated resulting a ball moving at velocity ($v_3 = v_2 + v_1$ or $3v_1$).

The Canadian Light Source Synchrotron uses a radio frequency cavity, not magnets, to accelerate electrons to nearly the speed of light, but the results are similar. This demonstration can easily lead into a discussion of the process at CLS. In very plain language, our linear accelerator uses microwave energy in a series of vacuum cavities each with a higher energy. As the electrons pass through each cavity they pick up energy and speed to match the cavity they are in. The electrons are accelerated to nearly the speed of light in fractions of a second.

Activities

1. Place the magnets a few cm apart on a ruler with a grove or corner moulding. Varying the distance between magnets will produce different results.

2. Place at least 2 balls behind each magnet. Varying the number of balls behind each magnet will also produce different results.

3. Hold the first ball a short distance from the first magnet and release it so that the ball moves slowly towards the magnet. If the magnet isn't strong enough to pull the ball immediately, gently push it so that it rolls slowly towards the magnet.

4. Catch the last ball before it gets away.