Build a linear accelerator model

Activity worksheet answers

Your name _____

Task A: Prediction

What do you think will happen when you release one steel ball at the start of the track?

What actually happens: The ball will roll along the track. As it approaches the first magnet it will be attracted to the magnet and its velocity will increase. When it hits the magnet, the energy will be transferred across to the balls on the other side of the magnet, and the furthest one will be released, with a slightly increased speed than the original ball had

Task B: Change the variables

How could you change the starting energy of the first ball?

- Give it a harder push.
- Lift up the start of the track to add potential energy in the form of gravity.
- Use stronger magnets or larger groups of magnets.
- Increase the initial separation of the first ball from the first magnet.

Which other variables could you change?

- The number of magnets at each section of the track.
- The number of balls located next to each magnet.
- The angle of the track to change the potential energy of each ball.
- The type of magnet, e.g. use a stronger magnet.
- The initial distance of the first ball.

What do think will happen when you change each of these variables? Discuss in pairs.

Task C: Questions

Which types of energy are being demonstrated?

Kinetic energy, potential energy, magnetic potential energy, gravitational potential energy.

What kind of energy transfers are happening?

Magnetic (and gravitational potential energy if the track is tilted) is converted into kinetic energy.

When the moving balls strike the magnets or other balls, kinetic energy is converted into elastic potential energy; most of the elastic potential energy is then transferred back into kinetic energy. Some of the kinetic and elastic potential energy is irreversibly converted into small amounts of heat (due to friction and deformation) and sound.

Where does the kinetic energy of the accelerating balls come from in the system?

When setting up the system, we add some energy:

- Kinetic energy (derived from chemical energy) from the person who puts the first ball in place and gives it a push
- Gravitational potential energy if the track is set at a sloped angle

Magnetic potential energy due to the interaction between the magnets and the ferromagnetic balls is the main reason for the increase in the kinetic energy of the balls.

Explanation: Larger separation of interacting objects corresponds to a larger potential energy. Thus, the magnetic potential energy depends on the spatial configuration of the balls and magnets: it is larger before the first ball hits the first magnet and smaller when the first ball has just hit the first magnet and the second ball is about to leave its initial position. This decrease in the magnetic potential energy of the system translates into the increase in the kinetic energy: the second ball is faster than the first one. If the track is set at a sloped angle, this increase in the kinetic energy is enhanced by the decrease in the gravitational potential energy.

Optional extension: Measuring acceleration

Measure the precise distance between each set of magnets.

Time how long it takes from the first ball being released to each strike. You may find it easier to film it using the slow-motion function on a smartphone.

Using these measurements, determine the average speed of each ball.
Example values are given below.

Ball number	Distance travelled (m)	Time taken (s)	Average speed (m/s)
1	10 cm = 0.1 m	1 second	0.1 m/s
2	0.1 m	0.5 s	0.2 m/s
3	0.1 m	0.25 s	0.4 m/s

By how much does the kinetic energy increase between each impact?

In this example, the speed approximately doubles between each impact

Co-funded by the European Union

The work presented on this document has received funding from the European Union project Accelerating Teaching (Agreement number 2022-1-SE01-KA220-SCH-0000889631). The content of the document is the sole responsibility of the organiser, and it does not represent the opinion of the European Union, nor is the European Union responsible for any use that may be made of the information contained.