Zip line challenge

Designing and making a zip line for a toy

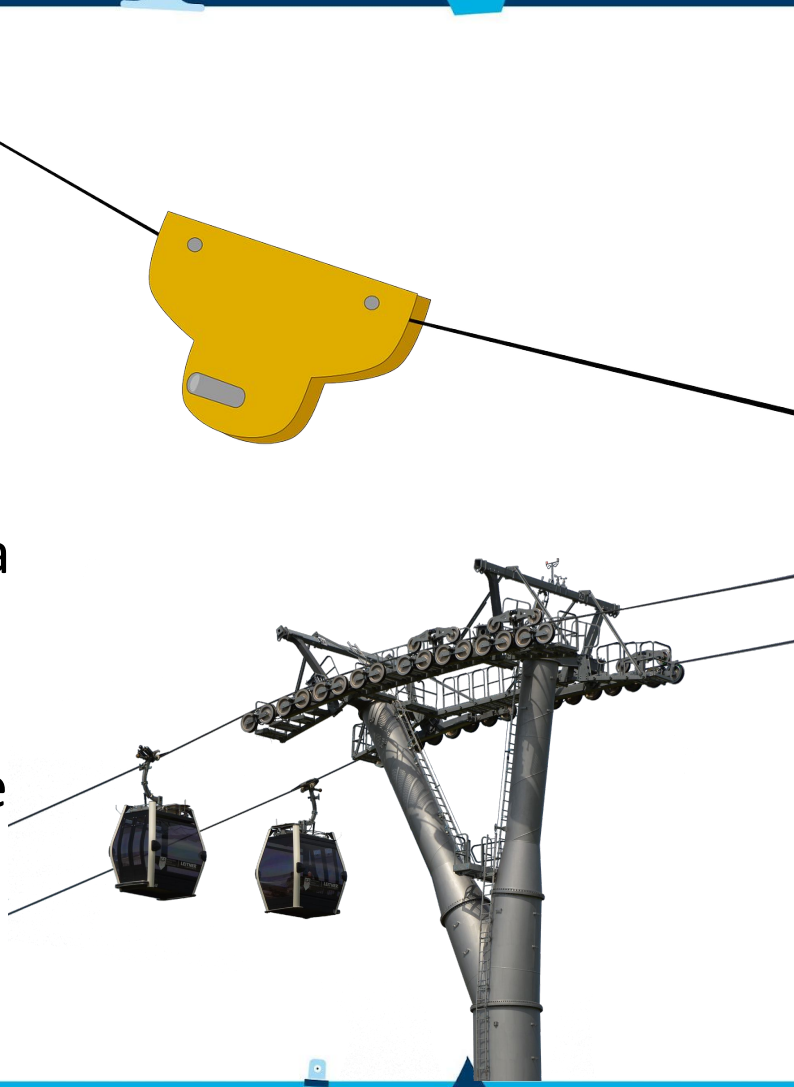
Resources

You will need:

- String or thin rope: 10m should be enough
- A paper clip or some stiff wire
- Sticky tape
- A tape measure or ruler
- A protractor
- A passenger for your zip line
- A stopwatch or a stopwatch app on your phone
- Somewhere to experiment!

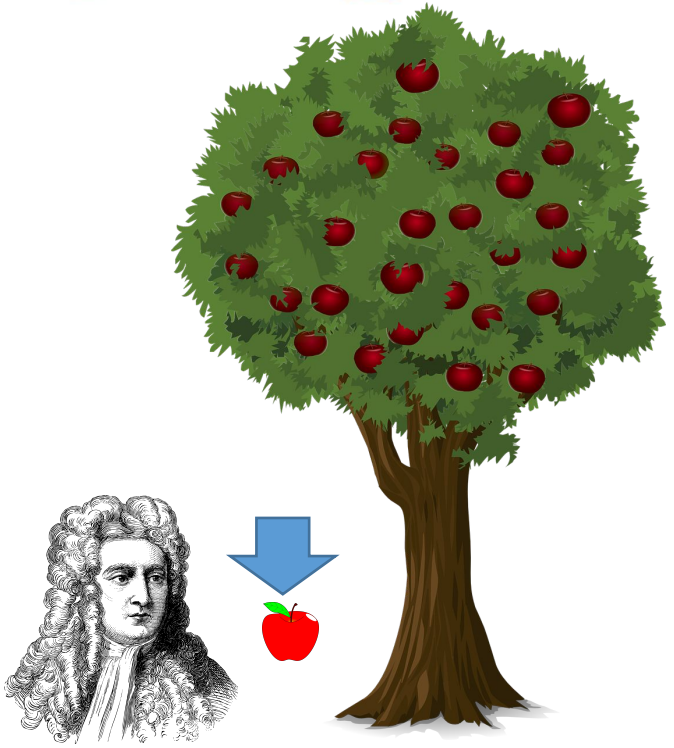
Introduction

- Zip lines are becoming a common sight at theme parks and attractions across the world.
- They use very clever engineering to keep the passengers safe and still have a great time.
- They use cables like cable cars and ski lifts, but no motor – the users move due to gravity.



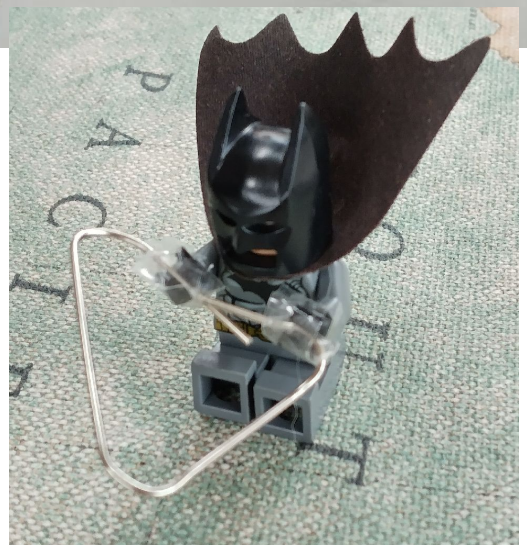
The Science

- Gravity pulls things on our planet down towards the centre of the Earth.
- It has existed as long as the universe – but was ‘discovered’ by Sir Isaac Newton in 1687.
- Something sliding down a zip line will be pulled from the top to the bottom.
- The energy gained by being ‘at the top’ will be turned into speed as the object slides down.
- However - some of the energy will be turned into heat or noise, as friction tries to slow the object down.



Step 1 – Making the harness

- Friction is the force that stops things sliding easily. Friction is your enemy! The ‘passenger’ needs to be able to slide well down the zip line.
- Make a harness for your passenger out of the paper clip or wire.
- The triangle shape means the passenger won’t slip sideways.
- Fasten your passenger to the harness safely using sticky tape.



Step 2 – Attaching the start of the zip line

- Find a place where you can attach one end of the zip line high up. This is called an ‘anchor point’.
  - *You could use a tree or fence post outside.*
  - *The top of a wardrobe or a desk works too.*
- The anchor point needs to be high enough to give a good steep angle on the zip line, but not so high that you need to climb to get up there.
- Attach the string or rope to the anchor point – it needs to be very secure so that it doesn’t slip. You could tie it round something, put weights on it or use sticky tape.

Step 3 – Attaching the bottom of the zip line

- Pass the string through the harness on your passenger.
- Now find somewhere to attach the bottom end of the zip line.
- It needs to give a good angle to the string (line) so that your passenger can slide down under the force of gravity - but not too steep, or the passenger will just fall down the string and crash. That would be no fun at all.
- You will need to adjust the end of the line so trap it under something like a chair leg, a rock or a heavy book. The line needs to be tight.

Step 4 – Trial run

- Try the Zip line to make sure it works. Take your passenger to the top and let go.
- If the passenger ‘stalls’ on the line stops before the bottom:
  - *If the string is too slack, tighten the ends.*
  - *If the string is too rough and there is too much friction, increase the slope.*
- Make your improvement to be ready for testing.

Step 5 – Testing

- Measure the angle of your zip line using the protractor (or calculate the angle using Maths!).
- Bring your passenger to the top of the zip line.
- Using the stopwatch, time how long your passenger takes to get from the top to the bottom.
- Make a table and write down the time and the angle.
- Repeat the test with different angles. How does the angle affect the time?

Test	Angle, degrees	Time, seconds
1		
2		
3		
4		
5		

Extension Activities

- Can you make a zip line that takes exactly 15 seconds to run?
- Can you try a bigger, heavier passenger? How does the weight of the passenger affect the time? What is the heaviest passenger that you can use?
- Can you try working out the angle from the height and length? (For this one see calculating the angle on the next slide).

Calculating the angle

- Working out angles is easy if you know about trigonometry!
- We can measure two sides: the opposite (height) and adjacent (distance across the floor).
- SOHCAHTOA tells us we must use tangent.
- Find the angle from your calculator using:

$$\tan^{-1}(\text{opposite} / \text{adjacent}) = \text{angle}$$

- The angle can be written into your notes to see what is the most effective angle for the line.