Breaking the fall; what a drag!

Do you think when a person jumps out of a plane from a very high altitude, they have ever wondered how their parachute works or how it's going to slow them down to a safe landing speed? Why does a parachute break the free fall so well and what design features are most important in slowing the descent?

Figure 1 - Materials required.

Thankfully things have moved on from the initial parachute drawings and sketches made by Leonardo Da Vinci many centuries ago [1] and are continuing to evolve today to meet the global demands of the armed forces, airlines and skydiving enthusiasts [2].

Whilst parachutes come in a variety of shapes and sizes, they all work on the same general principle using the force of air resistance to reduce the speed of falling.

As a parachutist is in free fall, the force of gravity is pulling him/her toward the ground. The force of gravity can make an object fall very fast! At first, the force of gravity is much greater than air resistance.

- As the parachutist speeds up the force of air resistance increases
- Soon the force of air resistance has increased until it is equal and opposite to that of the force of gravity. The parachutist is falling at what is called terminal velocity
- The parachute is pulled increasing the force of air resistance due to the parachute having a much larger surface area than the parachutist
- Air resistance decreases as the parachutist slows down
- When air resistance is once more equal and opposite to the force of gravity, the parachutist is again falling at a steady speed. This new terminal velocity is much smaller, and the parachutist can land safely.

In the following investigation we will conduct a 'Fair Test' on the effect of air resistance on the speed of a parachutist's descent. We will change only one variable, in this case the surface area of the parachute [3]. All other variables will be kept constant, thus allowing an investigation on how the area of the parachute affects the time it takes for the parachutist to reach the ground.

Prior to starting the investigation, the activity found at the following links gives a quick and simple introduction to air resistance that will provide an understanding of the effect surface area has on speed of descent [4,5]. After carrying out the activity, children should be able to make a more informed prediction as to which parachute, they think will work best and give reasons for their decisions.

Figure 2 - Cut the bottom sealed section of the black bin bag.

The following link provides a great visual for explaining and demonstrating to the children what happens when a parachute cord is pulled [6].

Materials required

- Black bin bag
- Scissors
- Ruler
- Sewing thread
- A small empty Pringles tub with lid (keep at least 15 Pringles for the investigation)
- Sellotape
- Stopwatch to time the descent.

Preparation time

Set the Pringles crisps to one side as these are going to act as our parachutists!

Cut open the black bin bag by first cutting the bottom sealed section off, then cutting up the long edge to make a single layered flat sheet of plastic (Figure 2). >>

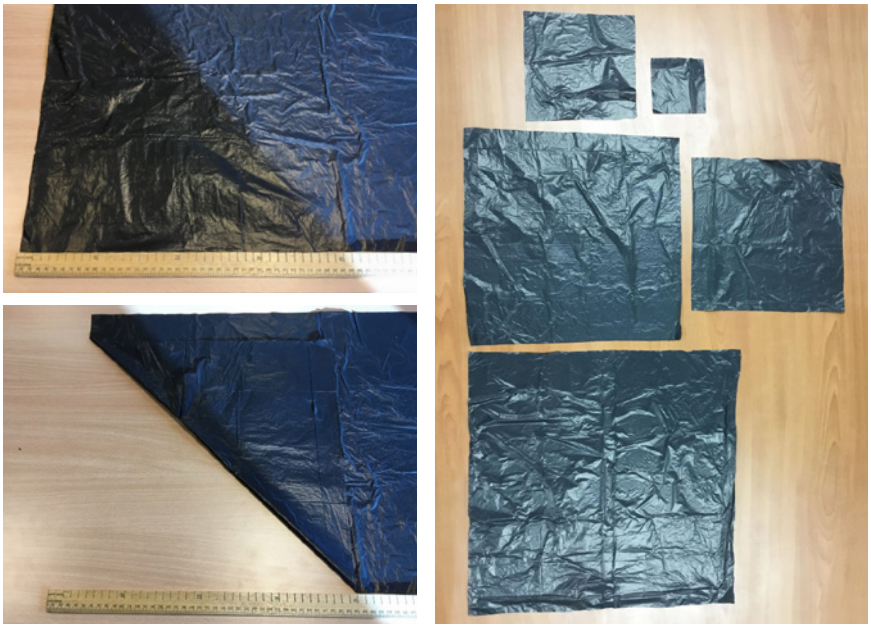

Figure 3 - Measure and cut out all the squares to the desired size of parachute.

Figure 4a - Measuring the thread photo.

Figure 4b - Attaching the thread to the parachute.

Using your ruler measure along the plastic sheet to the desired size of parachute (Figure 3) and cut out all the squares to the sizes detailed in the Table 1 below.

- Cut 8 x 30 cm lengths of thread (Figure 4a).
- Tie the thread tightly at each of the four corners of each square or Sellotape into place (Figure 4b). If using Sellotape, it is important to try to ensure that the same quantity/weight was used on each square of plastic to continue as a fair test.
- Taking care not to cross the threads, tape each one to the Pringles tube about 2 cm down from the top and evenly spaced round the tube. This allows even weight distribution on the parachute and prevents a twisted descent. We found that drawing a cross on the lid helped (Figure 5).
- What is the purpose of the Pringles tub? What would happen to the parachute if there was no pringles tub attached?
- Your parachutes are now ready to test! At this stage there is great opportunity for discussion about predicting which parachute is going to work the best (also discussion about what constitutes 'working best'?) and giving their reasons why.

Investigation time

Remember the left-over Pringles? You now need to place 1 of these Pringles in the tin and put the lids on (remember the Pringles are representing your parachutists). The parachutes must be dropped from the same height each time (otherwise there would be more than one variable). Therefore, it may be best for an adult to stand and reach up as high as they can then drop each parachute as this keeps the test as fair as possible. The pupils >>

Figure 5 - Pringles tube.

Size of parachute in centimetres	Time to reach the ground in seconds			Skydiver (Pringle) survived?	Mean time to reach the gound in seconds
	Drop 1	Drop 2	Drop 3		
5 x 5					
10 x 10					
15 x 15					
20 x 20					
30 x 30					

Table 1 - To find the mean of the 3 drops add them together and divide by 3.

Figure 6 - The teacher then holds the parachute as high as possible and drops.

should record the time taken from the adult releasing the parachute to the Pringles tin hitting the ground (Figure 6).

One point to keep in mind is that in accordance with health and safety in schools no child should stand on a table or chairs to increase the height of the drop.

The teacher then holds the parachute as high as possible and drops.

The children can use a stopwatch or another timer to measure how long it takes for each parachute to fall to the ground and record the time in Table 1 the timings will be short! They should then check to see if the Pringle in the tin has survived. Repeat the drop twice more for each parachute and record the times.

Repeat the whole experiment for the remaining parachutes of varying surface areas, making sure the same drop height is used.

If a result does not follow the predicted pattern, why not and can it be explained? This could be due to errors in recording timing such as starting the stopwatch late if the time recorded is much less. Should this result be kept in the average? Advice would be to retest the drop.

How could we make alterations to all the parachutes to increase the survival rate of our parachutists whilst keeping the investigation a fair test? How does cutting holes in the canopy of the parachute affect drop time?

This investigation could also be done with each group in the class changing a different variable. For example: different types of materials used for the canopy, changing the size of the material, change the shape of the canopy, altering the mass attached, changing the height the parachutist is dropped from [7]. <<

Experiences and Outcomes

Forces
- By investigating how friction, including air resistance, affects motion, I can suggest ways to improve efficiency in moving object - *SCN 2-07a*.

Topical science
- Through research and discussion, I have an appreciation of the contribution that individuals are making to scientific discovery and invention and the impact this has made on society - *SCN 2-20a*.

Technologies

From the organiser - Design and construct models/product
- I can design and construct models and explain my solutions - *TCH 1-09a*.
- I can extend and enhance my design skills to solve problems and can construct models - *TCH 2-09a*.

Data and analysis
- I have explored a variety of ways in which data is presented and can ask and answer questions about the information it contains - *MNU 1-20a*.
- Having discussed the variety of ways and range of media used to present data, I can interpret and draw conclusions from the information displayed, recognising that the presentation may be misleading - *MNU 2-20a*.

Extension task through a literacy context

Imagine you are flying along in your airplane. Suddenly, the engine stops, and you need to bail out. Luckily, for you there is a parachute close to hand to help you land safely.

Could the children through the knowledge gained from this investigation suggest the best way to slow the plane's descent and allow it to land safely?

References

[1] http://www.da-vinci-inventions.com/parachute.aspx (accessed March 2019).
[2] https://skydivemonroe.com/blog/why-do-parachutes-come-in-different-shapes-and-sizes/ (accessed March 2019).
[3] https://www.sciencebuddies.org/science-fair-projects/science-fair/doing-a-fair-test-variables-for-beginners (accessed March 2019).
[4] https://www.sserc.org.uk/wp-content/uploads/2019/01/cone-template-.pdf (accessed March 2019).
[5] https://www.sserc.org.uk/wp-content/uploads/2019/02/Cone-template-instructions.docx.
[6] https:// ://www.bing.com/videos/search?q=Terminal+Velocity+Science+in+Focus&&view=detail&mid=1F3B000BC62CB4E4C77A1F3B000BC62CB4E4C77A&&FORM=VDRVRV (accessed March 2019).
[7] https://www.sserc.org.uk/wp-content/uploads/2019/04/The-forces-acting-on-a-parachutist.docx.