Parachute Investigation

Aim

The aim of the experiment is to investigate how each of several different weights of varying mass attached to a parachute in turn can influence the gravitational pull and air resistance forces acting on it, consequently affecting the time it takes to reach the ground when dropped from a specific height.

Preliminary Work

Forces are measured in Newtons (N), named after Isaac Newton who invented this unit. We cannot see them but instead we can see their effects on objects, so forces are described in terms of what they do. They can cause objects to turn, change speed, direction or shape.

The forces acting on a falling parachute are gravity and air resistance and these are the two forces which affect the speed at which the parachute falls.

Air resistance (also called drag) is when air molecules collide with an object's leading surface. This is the opposite force to gravity, and can slow falling objects down.

The actual amount of air resistance encountered by the object depends on a variety of factors. The two most common factors which have a direct effect upon the amount of air resistance are:

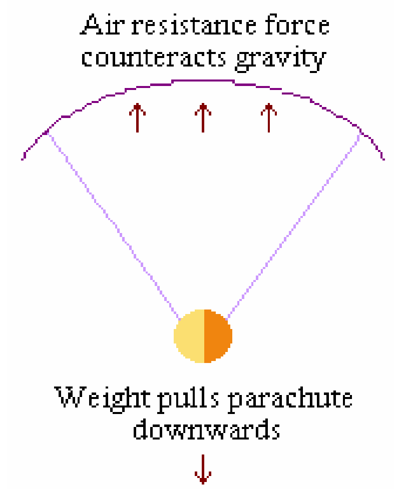
- the speed of the object
- the cross-sectional area of the object

Increased speeds and increased cross-sectional areas result in an increased amount of air resistance.

Gravity is what causes objects to fall downwards. If there was no air resistance, all falling objects would accelerate at 10m/s/s ($10m/s^2$) because there would be no other force to change the speed.

Acceleration is the rate at which the velocity of an object changes over a period of time. It is measured in m/s^2, and it tells you how much the velocity will change each second. When air resistance is present, objects with different mass accelerate at different speeds.

Parachutes, as used in this investigation, are effective because they have a very large surface area compared to the weight attached and so have a lot of air resistance acting on them to counteract the downward pull of gravity on the weight.



Pre-test

Before the actual experiment, a pre-test was carried out to ensure accuracy and that all the correct factors will be used for the final experiment.

These are the 5 weights which will be used:

- ½ oz (14.1g)
- 1 oz (28.4g)
- 1 ½ oz (42.6g)
- 2 oz (56.8g)
- 2 ½ oz (71.0g)

The parachute was dropped every time from a height of about 7ft. Each of the 5 weights was dropped 3 times and the results added together to give the overall average falling time for the weight.

Pre-test Results Table

	Time Taken For Each Experiment (sec)			
Mass (g)	1	2	3	Average
14.1	1.17	1.10	1.13	**1.16**
28.4	0.85	0.89	0.86	**0.87**
42.6	0.78	0.71	0.75	**0.75**

56.8	0.69	0.71	0.68	**0.69**
71.0	0.65	0.66	0.67	**0.66**

For the actual experiment I am going to drop the parachute from a higher height than that which was used for the pre-test because hopefully this will achieve more reliable results as it will have had longer to fall and to achieve the terminal velocity.

The weights that were used will also be used for the next experiment, as these were the ones available which weren't too light and caused the parachute to drift and spin a lot, or too heavy and made the parachute crumple.

Results will be recorded to 2 decimal places as this gives reasonable accuracy and allows comparison between results, but makes points relatively straightforward to plot on a graph.

Prediction

When dropped, each weight will initially cause the whole parachute to accelerate, and as it gains speed it encounters an increasing amount of opposing upward air resistance force.

The parachute will continue to gain speed until the air resistance hitting its surface increases to a large enough value to balance the downward force of gravity. At this point, the net force is 0 Newtons, and the parachute stops accelerating. Then the parachute will have reached its terminal velocity and it will continue to fall at a constant speed until intercepted by a solid object, such as the ground.

Weights which have more mass experience a greater downward force of gravity. They will have to accelerate for a longer period of time before there is sufficient upward air resistance to balance the large downward force of gravity.

So in conclusion, the heavier weights (56.8g, 71.0g) will fall faster than the lighter weights (14.2g, 28.4g) because they take longer to reach a terminal velocity due to a larger force of gravity acting on them. They build up more and more air resistance as they accelerate, approaching a terminal velocity when the air resistance force equals the gravity force.

Lighter weights on the other hand, would reach a terminal velocity more quickly, because of having less gravity acting on them due to them weighing less and so fall at a slower speed.

List of Equipment

- 30cm Ruler
- Scissors
- Plastic parachute (30cm x 30cm) & string (4 pieces, each 35cm)

- Small plastic container to hold weights
- Stopwatch
- 5 weights:
  - ½ oz (14.1g)
  - 1 oz (28.4g)
  - 1 ½ oz (42.6g)
  - 2 oz (56.8g)
  - 2 ½ oz (71.0g)

Method

- Firstly, I will make the parachute. This will be done by cutting a square shape from a plastic carrier bag measuring 30cm across and using a ruler for accuracy. A hole will be made in each corner of the square using scissors and a piece of 35cm long string threaded through each. The ends of the strings will be joined together and a small plastic container tied there in which each weight will be placed.
- Next, each weight in turn will be placed in the plastic container and the parachute dropped 3 times for each weight from a height of approximately 7ft for the pre-test. A stopwatch will be used to time how many seconds it takes to reach the floor, and the results of the pre-test will recorded in a table.
- Then the actual experiment will be carried out, the same way as the pre-test, but with a height of 13ft instead of 7ft, and again recorded in a table.
- After calculating the average time for each weight, the averages will be plotted on a graph.

Fair Test

An important way in which I hope to keep the test fair is by dropping the parachute 3 times for each weight, instead of just once. This should increase the reliability of my results because any times taken and recorded which are not valid will be easy to spot if they are very dissimilar to the other two results taken for that weight.

When recording my results, I will write the times in seconds to 2 decimal places, as this makes it easier to compare between the different results and spot any anomalous ones.

An average of the 3 results will be calculated for each of the 5 weights, which should provide an accurate overall time to then be plotted on a graph.

The same brass weights and parachute will be used throughout the experiment. Care will be taken to ensure that no factors are altered which could change any results.

Every time the parachute is dropped, it will be from the same height. If the parachute comes into contact with an object during it's descent, spins too much or drifts too far, then the time taken will be considered invalid and the process repeated.

Safety Precautions

This is not a particularly dangerous experiment, however it is important to be aware of any risks that could be involved. For some parts of the experiment there may be many people working in a relatively small space, and as the practical part involves dropping weights from a height onto the floor where people may be walking, care should be taken not to drop the weights on anyone's foot or place a foot under where the weight will be dropped.

Weights or equipment which is not being used will be kept in a place where it can't be knocked, lost or considered a hazard.

Results Table

	Time Taken For Each Experiment (sec)			
Mass (g)	1	2	3	Average
14.1	2.18	2.14	1.99	**2.10**
28.4	1.63	1.59	1.57	**1.60**
42.6	1.43	1.46	1.41	**1.43**
56.8	1.27	1.29	1.28	**1.20**
71.0	1.02	1.05	1.08	**1.05**

Conclusion

The final results were what I had expected and support my prediction that heavier weights fall faster than lighter weights because each weight at first causes the whole parachute to accelerate, then gain speed until reaching its terminal velocity when the amount of opposing upward air resistance force increases enough to match the gravity and then fall at a constant speed.

These results prove that the weight on the parachute affects the speed at which it falls and also the time it takes to reach the ground. This is because Weights which have more mass experience a greater downward force of gravity. They will have to accelerate for a longer period of time before there is sufficient upward air resistance to balance the large downward force of gravity.

From the graph I can see that generally the points form a downward-sloping gentle curve, relatively close together but with the first point (the lightest weight) higher than might be expected if compared with the position of the other points.

Evaluation

Overall I think the experiment went well and the results collected at the end were valid and reasonably accurate, though accuracy could have been improved, but on the other hand any discrepancies that occurred during the test are accounted for.

There were no anomalous results, though they could have been made more reliable by taking more care to control factors which could influence them, such as the temperature of the room – could a warmer room have affected the parachute, as warm air is less dense and rises?

The test might also have been made fairer by dropping the parachute at exactly the same height each time, stopping the stopwatch at the exact moment it touched the ground and ensuring that the strings stayed untangled and therefore were the same length. I considered using a different method of attaching the weights to the parachute because the weight of the plastic container might have affected the fall, but I decided to use it as it was the simplest way and didn't weigh very much and also counted as part of the structure of the parachute anyway.

I could also have only accepted results for which the parachute fell straight down and didn't spin or float diagonally, but this proved to be too time-consuming as it seemed that the parachute tended to do what it wanted most of the time.

If I were to extend the investigation further, I could do more investigations and vary different factors such as the room temperature, the string length or parachute size, how holes in the parachute affect results, and find different ways of improving results, for instance how to control the parachute and stop it spinning or drifting to the ground at an angle, and how to prevent the parachute from crumpling or the strings becoming tangled.