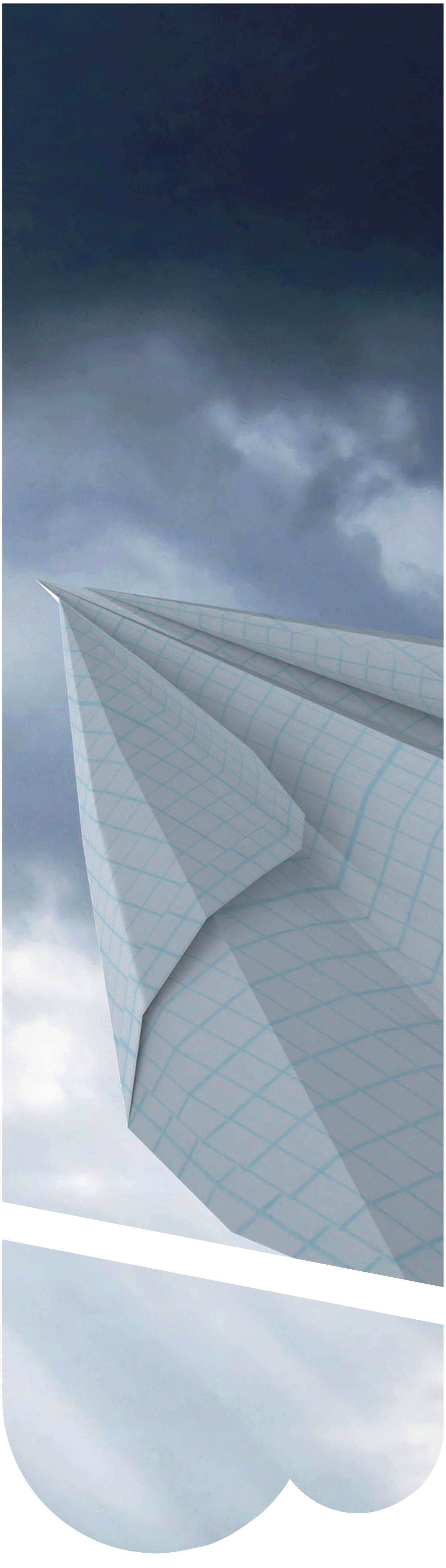
Name: ______________________



Speed
Investigation

BEYOND SCIENCE

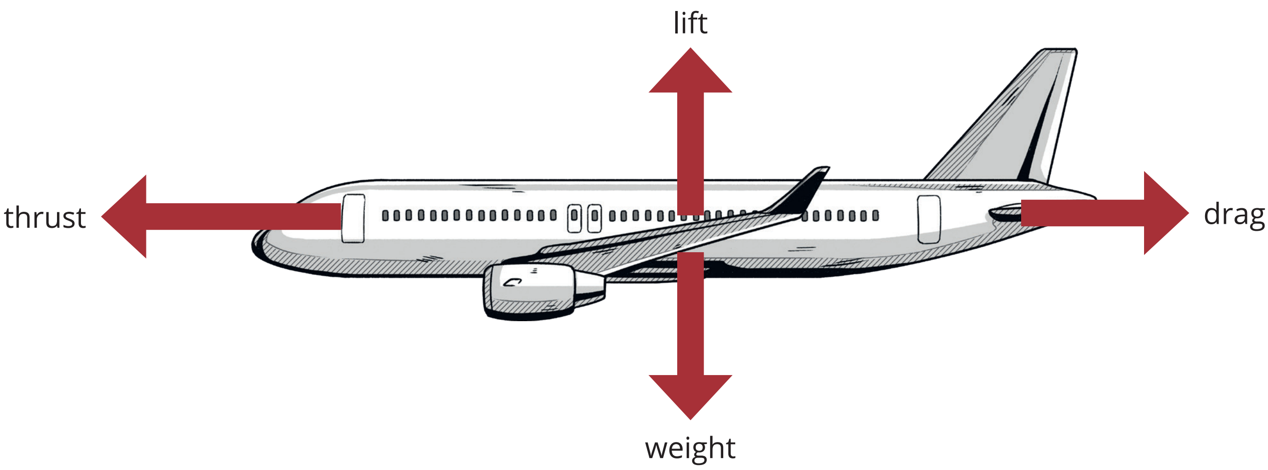
Contents

Introduction

Aeroplanes are designed to move through the air between destinations in as little time as possible. The forces acting on a plane affect its speed. The force from the engine that moves the aeroplane forward is known as thrust. Drag is the term used for the friction experienced by the aeroplane as a result of air particles passing over it as it moves. The forwards-acting force, thrust, must be greater than drag, for the aeroplane to move in a forward direction.

Aeroplanes are designed to be streamlined, to allow air particles to flow over their surfaces more efficiently, reducing the effect of drag.

The mass of the aeroplane will affect the downwards force of weight. The more mass the aeroplane is carrying, the greater the downward force will be.



Paper planes act as a model of aeroplanes and are affected by the same forces in a similar way. Creating a paper plane which is more streamlined reduces the effect of drag and it flies more quickly over a greater distance. Using lighter paper reduces its mass, also improving its flight.

You will be investigating the factors which affect the speed of paper planes. The average speed of an object can be calculated using the following equation:

average speed (m/s) = distance travelled (m) ÷ time taken (s)

This means that in your investigation you will need to be able to measure the distance your paper plane travels as well as the time it takes to travel that far.

Task 1: **Choose an Aim for Your Investigation**

The aim of the investigation is what you are trying to find out. Your investigation should allow you to calculate the speed of the paper plane you threw. However, you may also like to investigate how an independent variable affects its speed.

For example:

- To find out how the mass of the paper plane affects its speed.
- To find out how the size of the paper plane affects its speed.
- To find out how the design of the paper plane affects its speed.

You could use one of the investigation aims listed above or come up with your own idea. Remember, you must be able to calculate the speed of the plane in your investigation.

You should set out your aim in the form:

To find out how ____________________ **affects** ____________________ .

Write the aim of your investigation below.

____

____

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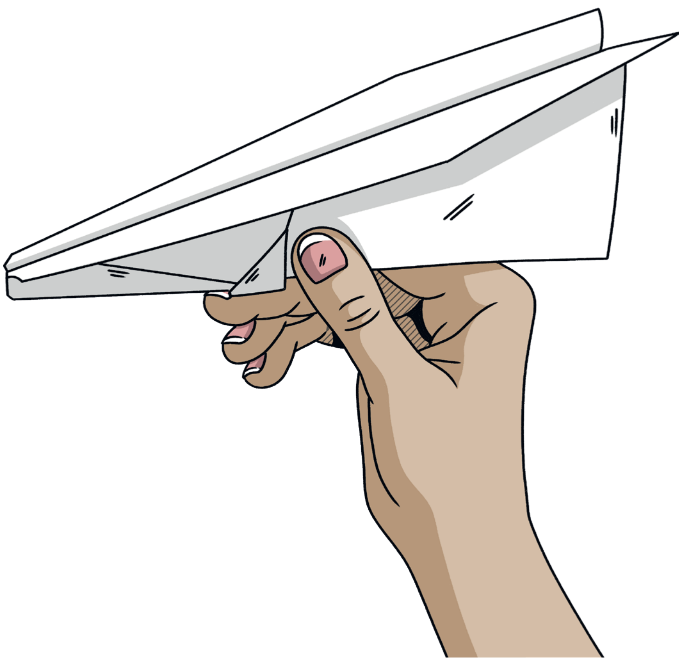


Task 2: **Identify Your Variables**

Independent Variable

The **independent variable** is the variable that you change or select the values for.

When you are planning an investigation, you need to decide what values you will use for the independent variable. The values might be measurements, for example the mass of an object, or categories, such as the different types of chemicals you will test.

What is the independent variable in your investigation?

What values will you use for your independent variable?

Dependent Variable

The **dependent variable** is the variable that is measured for each change of the independent variable.

What is the dependent variable in your investigation?

What measurements will you need to take to be able to calculate the dependent variable?

How will you take these measurements?

Control Variables

A **control variable** is one that may, in addition to the **independent variable**, affect the outcome of the investigation and therefore must be kept constant.

When planning the investigation, you need to identify the other variables that might affect the dependent variable and plan how to control them.

How might the way the paper plane is released affect its speed?

How might you control the way the plane is released to prevent this?

How might your results be affected if you start the timer before the plane has been released, or stop the timer before the plane has landed?

How might you control the starting and stopping of the timer to prevent this?

List the variables which you are going to control in your investigation below.

Task 3: **Write a Method**

Method

A **method** should set out, in a logical order, how the investigation will be carried out.

It should be detailed enough that other people could follow your method to repeat the investigation.

Your method should produce **valid** results. An experiment gives valid results if it is a **fair test** and provides **repeatable** results.

- If a variable should be controlled but isn't, then the experiment will not be a fair test. Your method should include the ways you will manage the control variables you identified.
- Your method should allow you to check whether your results are repeatable. How many repeats will you include, will you calculate a mean?
- You should include all the values of your independent variable that you will test.
- You should describe how your dependent variable will be measured.
- You should describe how you will use any equipment you need

Example Method

1. Collect three sheets of paper of different sizes. Follow the instructions on the **Aeroplane Construction s**heet to make three paper planes of different sizes.
2. Outside, use a tape measure to place two cones 5 m apart. These are 'start' and 'stop' cones.
3. One person stands behind the 'start' cone holding the first plane. A second person stands by the 'stop' cone with the timer.
4. The plane will be released at head height towards the 'stop' cone. When the person throwing the plane releases it, they shout 'start.' At this point, the person holding the timer starts it.
5. When the plane passes the 'stop' cone the timer is stopped.
6. If the plane does not reach the 'stop' cone the throw is repeated.
7. Steps 4-7 are repeated until there are three results for the first plane.
8. Steps 4-8 are repeated for the other two planes.

Write your method below.

Task 4: **Risk Assessment**

A **risk assessment** is used to identify the potential hazards and the harm they can do when carrying out an investigation. It includes the precautions that will be put in place to minimise the risk of the harm occurring.

Consider the equipment and method that you will use for this practical work. Record the potential hazards and harm they can do in the table below, then describe some actions you will take to minimise each risk.

Remember: the hazards you identify should be **specific** to this investigation.

Hazard	Harm It Can Do	How You Will Minimise the Risk

Task 5: **Design a Table to Record Your Data**

Results Table

Before you carry out your investigation, you need somewhere to record your results. It is important to make sure your variables are in the correct place in your table. The independent variable goes on the left-hand side and the dependent variable (with space for repeats) goes on the right-hand side.

You need to think about how to record your distance and time measurements in a clear way during the investigation. Your table of results should show how the **speed** of the paper plane depends on the independent variable that you are changing.

An example is shown below.

Plane Size	Time for Plane to Travel 5 m (seconds)				Average Speed (m/s)
	Repeat 1	Repeat 2	Repeat 3	Mean	
large					
medium					
small					

In this example, the distance travelled by the paper plane has been kept constant (5 m).

An alternate method might be to measure the distance travelled by the paper plane over its entire journey.

The mean time in seconds for each change of the independent variable can then be used to calculate the speed of each plane over 5 m.

average speed (m/s) = distance travelled (m) ÷ average time taken (s)

average speed of large plane (m/s) = 5 m ÷ ________________ (s)

average speed of medium plane (m/s) = 5 m ÷ ________________ (s)

average speed of small plane (m/s) = 5 m ÷ ________________ (s)

These values can be added to the final column of the results table.

Use the space below to plan how you will record your results. You should consider how you will record your measurements and design a table of results showing how your independent variable affects the speed of the paper plane.

Follow the checklist below to design your own table.

- [ ] I have used a pencil and ruler to draw my table.
- [ ] The **independent** variable (the variable I will change or choose the values for) is on the left-hand side of the table.
- [ ] The **dependent** variable (the variable I will measure for each change in the independent variable) is on the right-hand side of the table.
- [ ] I have chosen a suitable heading for both variables.
- [ ] I have included the correct units for both variables.

Task 6: **Complete the Investigation and Record Your Results**

Remember:

- Record all the data to the same number of decimal places.
- Calculate your mean to the same number of decimal places as the measurements you recorded.

Example Data

Independent Variable (units)	Dependent Variable (units)			
	Repeat 1	**Repeat 2**	**Repeat 3**	**Mean**
value 1	8.9	3.4	9.1	

Anomalous Results

If one of your results doesn't fit the pattern shown by the other results, then it is an **anomalous result**. This will have been caused by an error such as reading a measurement incorrectly, starting a stopwatch too late or not controlling all the control variables. We discount anomalous results from the mean calculation.

Calculating a Mean

Step 1: Discounting any anomalous results, add together the measurements for each repeat of the first value of the independent variable.

Step 2: Divide this number by the number of repeat readings you took.

Step 3: Round your answer to the same number of decimal places as your measurements.

Worked Example

Step 1: 8.9 + 9.1 = 18 (the second repeat value is discounted as it is an anomalous result)

Step 2: 18 ÷ 2 = 9 (we only divide by two as only two measurements are considered)

Step 3: The measurements are given to one decimal place and therefore the mean value should be written as 9.0. This value can now be written into the final column of the results table.

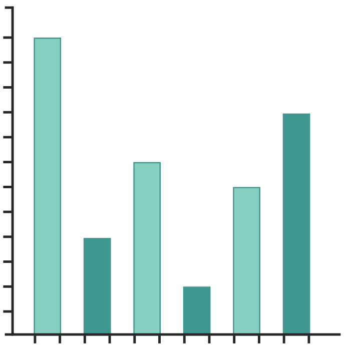
Task 7: **Display Your Results**

You may wish to draw a graph to display the results from your investigation. The type of graph you draw will depend on the type of data you recorded.

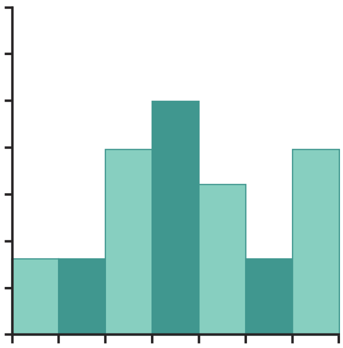
Discrete data can only take certain values - it fits into categories. For example, shoe size or number of students.

Continuous data can take any value within a range - it is measured on a scale. For example, height or time.

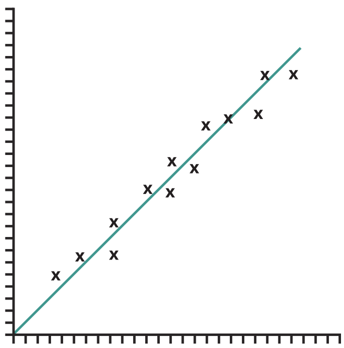
Sometimes, we might group continuous data into categories. For example, height might be divided into 141-145cm, 146-150cm, 151-155cm.



When one of our variables is discrete, we draw a bar chart.

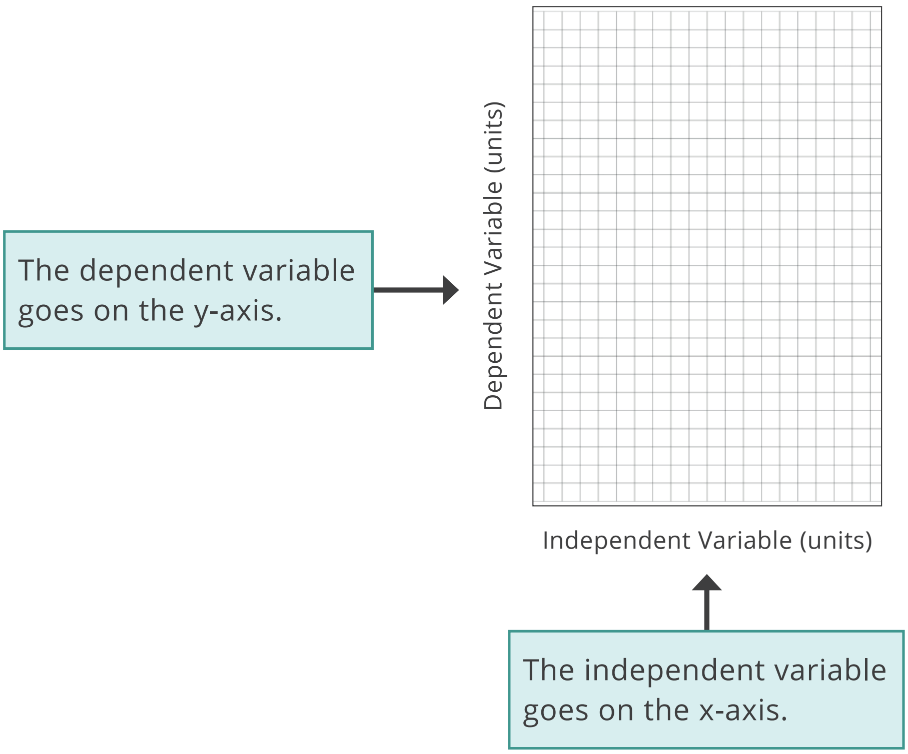


When continuous data is grouped into categories, we draw a histogram.



When both variables are continuous, we draw a scatter graph.

The axis labels on your graph should match the headings in your table. Do not forget to include the units.



Graph Checklist

Follow the checklist below to draw a graph of your results.

- [ ] I have used a sharp pencil and ruler.
- [ ] The type of graph I have chosen is appropriate for my data.
- [ ] The independent variable is on the horizontal (x) axis.
- [ ] The scale on the x-axis is divided into equal intervals and fits all of my data.
- [ ] The x-axis is labelled with the independent variable, including units in brackets.
- [ ] The dependent variable is on the vertical (y) axis.
- [ ] The scale on the y-axis is divided into equal intervals and fits all of my data.
- [ ] The y-axis is labelled with the dependent variable, including units in brackets.

If I have drawn a scatter graph:

- [ ] I have correctly plotted my data as small crosses and the points are visible on the graph.
- [ ] I have circled any anomalous results, if necessary.
- [ ] I have drawn a line of best fit as appropriate, ignoring any anomalous results. (Remember, a line of best fit may also be a curve.)

If I have drawn a bar chart:

- [ ] The bars are equal in width.
- [ ] The height of the bar is equal to the value of that category.
- [ ] There is a gap between each bar.

If I have drawn a histogram:

- [ ] There is no gap between the bars.

Draw your graph in the space below.

Task 8: **Write a Conclusion**

A **conclusion** is an explanation of what you found out in your investigation.

What was the effect of changing your independent variable on the dependent variable?

(Did it increase it, decrease it or have no effect? Which value of the independent variable gave the biggest increase or decrease?)

How do you know this?

(Use the data you collected to support the pattern you have identified.)

Why does this happen?

(Give the science behind your results.)

Task 9: **Write an Evaluation**

An **evaluation** is where you consider the quality of your method and the data you collected.

A **control variable** is one that may, in addition to the **independent variable**, affect the outcome of the investigation and therefore must be kept constant.

How successful were you at keeping your control variables the same throughout your investigation?

A measurement is **repeatable** if the same experimenter repeats the investigation using the same method and equipment and gets the same result.

Are the range and number of readings you took sufficient to see whether you have repeatable results?

Can you explain any anomalous results?

Evaluation continues on the next page.

An experiment gives **valid** results if it is a **fair test** and provides **repeatable** results. If a variable should be controlled but isn't, then the experiment will not be a fair test.

Are the results of your investigation valid? How do you know?

How could you increase the validity of your results? (How could you overcome any weaknesses with your method?)

Glossary

anomalous	A result that doesn't fit the pattern shown by other results.
continuous data	Data that can take any value within a range. It is measured on a scale.
control variable	A variable that may, in addition to the independent variable, affect the outcome of the investigation. It must be kept constant.
dependent variable	The variable that is measured for each change of the independent variable.
discrete data	Data that can only take certain values. It fits into categories.
distance	How far an object moves, or the length between two points, measured in metres (m). It is a scalar quantity.
drag	The friction experienced by an object moving through a fluid as a result of particles passing over it. It acts in the direction opposing motion.
fair test	When only the independent variable has been allowed to affect the dependent variable. All other variables have been controlled.
fluid	A substance that has no fixed shape and can flow. It can be either a liquid or a gas.
friction	A force that resists the movement of two surfaces that are sliding (or trying to slide) across each other.
independent variable	The variable that you change of select the values for.
lift	The upwards force exerted on an object moving through a fluid.
mass	The amount of matter in an object, measured in kilograms (kg).
mean	The average of a set of numbers.
proportional	Where one variable directly affects another variable by a fixed amount. This relationship would have a straight line of best fit on a line graph.
repeatable	The same experimenter repeats the investigation using the same method and equipment and gets the same result.
speed	The distance travelled by an object in a specific time, measured in metres per second (m/s). It is a scalar quantity.
thrust	A forwards-acting force causing objects to move.
time	How long an event occurs for, measured in seconds (s).
valid	An experiment gives valid results if it is a fair test and provides repeatable results.
variable	A quantity or characteristic that can change an investigation.
weight	The force acting on an object's mass due to gravity, measured in newtons (N).

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