WOW sheet

What is air resistance?

Here is what ‘air resistance’ means in physical science:

> Air resistance is the result of collisions between an object's leading surface with air molecules.

In other words, air resistance is the equal and opposite force on an object traveling through the air.

Here’s an example

Imagine you are at the park and you throw a ball to a friend. After you let go of the ball, the ball is touching air the whole time it is traveling towards your friend. Air is made up of lots of molecules. Each molecule is an object. So, each time the ball hits an air molecule, **Newton’s third law** tells us that there is an action-reaction pair.

It might seem a bit strange, but you can think of all of the air molecules together being one ‘object’ that the ball is interacting with.

When object x (the ball) exerts a force on object Y (the air), then object Y (the air) exerts an equal and opposite force on object X (the ball).

Air resistance!

Air resistance is a special type of **friction** force also called a **drag force**.

A **drag force** is the resistance force caused by the motion of an object through a fluid, such as water or air. In other words, it's the resistance of the fluid reacting to the force of the object pushing through the fluid. The drag force acts in the opposite direction to the object's velocity.

Air resistance and objects

How does air resistance affect how an object moves? The answer depends on a few things. The key things are:

- the density of the air,
- the shape of the object,
- the velocity of the object, and
- the mass of the object.

Air density

The denser the air is, the more air resistance. This makes sense, because in denser air, there are more air molecules, so there are more 'objects' causing resistance.

The object's shape

The shape of the object matters too. If the object's leading surface (that is, the part that is pushing into the air first) is big and flat, then there is more of it to run into more air molecules.

Here's an example

Imagine jumping into a swimming pool. If you dive in head-first, with your arms over your head, there's only a small pointed leading surface and you slip into the water with only a little resistance. But if you bellyflop into the pool, there's a big, flat leading edge and the fluid gives a LOT of resistance!

The object's velocity

How the object is already moving, in other words, its velocity, also matters. The speed of an object is especially important. The faster an object is going, the farther it will travel in a given length of time. The further it travels, the more air molecules there are in the way. That means more air resistance!

The object's mass

You might think that the more mass an object has, the more air resistance it will experience. In fact, the opposite is true!

Newton's second law tells us that to get an object to **accelerate** you need an outside force. (In physical science, **accelerate** means changing how an object is moving by getting it to slow down, speed up or change direction.)

The size of the force you need depends on the mass of the object. The larger the mass, the more force you need.

Think of air resistance as a force that is trying to change how an object moves. The more mass an object has, the less air resistance is able to change its motion.

Here's an example

A bowling ball has a lot more mass than a balloon. If you drop either one, gravity will pull the object to the ground.

For the bowling ball, the air between your hands and the ground can't do much to slow down the ball as it falls. But the balloon has very little mass. The air resistance can do a lot more to change the balloon's acceleration, which is why it falls more slowly.

Want to see the maths? How much force would you need to stop gravity?

Newton's second law says **F**=$m\boldsymbol{a}$. Near the surface of the Earth, gravitational acceleration is $9.8\frac{m}{s^2}$. If the bowling ball has a mass of 5kg and the balloon has a mass of 10 grams (0.01kg) here's the force you would need:

$(5kg)\times(9.8\frac{m}{s^2})=49N$ → 49N of force to stop the bowling ball.

$(0.01kg)\times(9.8\frac{m}{s^2})= 0.098N$ → 0.098N of force to stop the balloon.

Air resistance isn't enough to stop the balloon. But it's a lot closer to stopping the balloon than the bowling ball!

Air resistance in physical science

You might be surprised to learn that in most physical science problems, air resistance is ignored! That is to say, physics problems often pretend like air resistance doesn't even exist!

For a lot of problems, this makes sense because air resistance as a force isn't actually all that large. When you are dealing with objects with a lot of mass, air resistance is very small, so you can 'ignore it' and you will still understand how an object is going to move.

You can't always ignore air resistance, however.

Air resistance matters a lot when you are dealing with objects with very little mass. Air resistance is also very important when you are trying to build things that are going to interact with the air.

Air resistance and engineering

An **engineer** is a problem solver. Some engineers design and build machines, systems, or structures that need to consider air resistance.

For these engineers, air resistance does matter. But the types of problems involving air resistance they are trying to solve can vary a lot.

Depending on what you are trying to do, air resistance can be a problem, or it can be part of the solution.

Here's an example

Sometimes air resistance causes problems that engineers need to solve. Engineers might design the shape of a machine to minimise air resistance. One example of this is the pointy nose of a rocket.

Engineers also use the force of air resistance to help them, however. One example of this is the wing of an airplane. Airplane wings use air resistance to create lift, which helps keep the plane in the air!