Tutor Packs

AS Level Physics

Chapter 4 – Materials

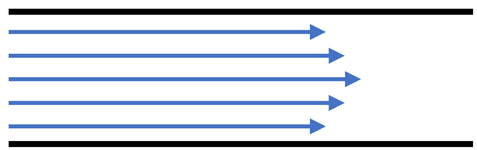
4.2.1 Drag (Edexcel Only)

Notes

Laminar and Turbulent Flow

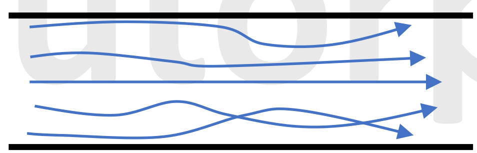
A fluid is a substance that can flow, like a liquid or a gas. The flow of a fluid is usually represented by streamlines. Fluids can be said to move in either laminar flow or turbulent flow.

Laminar flow is when fluid particles move in regular paths without mixing between adjacent layers of the fluid.



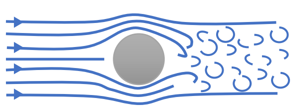
Laminar flow

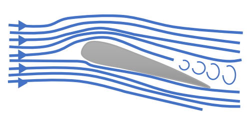
Turbulent flow is when fluid particles mix between layers and form separate currents and a s a result turbulent flow is frequently described as chaotic.



Turbulent flow

Aerodynamics is the study of objects travelling through air and the forces acting upon them. For example below:





Laminar flow is characterised by smooth, continuous streamlines that do not cross over one another as there are no abrupt change in direction and speed. In contrast, turbulent flow is chaotic and features swirling vortices or eddy currents that cause the streamlines to be discontinuous.

Viscosity

Viscosity is a measure of a fluid's resistance to flow. For example, water is less viscous than honey and so water tends to flow more easily.

Viscosity can also be used to describe the internal friction of a moving fluid. For example, honey resists motion due to its molecular structure giving it a high internal friction and for this reason honey has a high viscosity.

On the other hand, water has a low viscosity compared to honey allowing it to flow easily due to its molecular structure resulting in little friction when it moves.

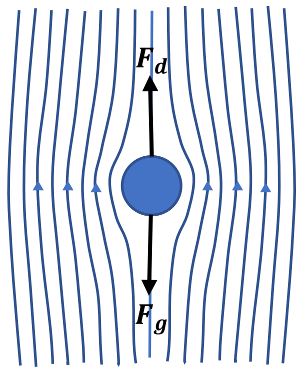
Viscosity is effected by temperature:

In (most) liquids – viscosity of a liquid decreases, as the temperature increases.

In gases – viscosity of a gas decreases, as the temperature decreases.

Stokes' Law

When an object moves in a fluid, it will experience a resistive force known as the viscos drag force. The viscous drag force is labelled in the diagram below as (F_d):



Stoke's law can be used to calculate the viscous drag force acting on an object. However, to use this law the following conditions must apply:

- The object moves at a low speed with laminar flow.
- The object is small and spherical.

Stokes' law states that the viscous drag force (F) experienced by a small, slow moving spherical object with laminar flow can be calculated using:

$$F = 6\pi\eta r v$$

Where:

η = is the viscosity of the fluid

r = is the radius of the object

v = terminal velocity of the object

Everyday Applications

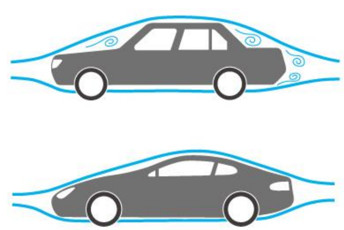
Aerodynamics examines how objects move through the air and the forces that influence them. Analysing airflow around objects enables us to calculate the lift forces required for an aircraft to counteract gravity and drag.

Aerodynamics is also relevant to vehicles. On calm, non-windy days and at low speeds, the effects of air resistance on vehicles are hardly noticeable. However, at high speeds or on windy days, air resistance significantly impacts a car's acceleration, handling, and fuel economy.

Enhancing a vehicle's aerodynamics reduces drag, contributing to greater fuel efficiency. As a vehicle encounters drag, it resists forward motion, requiring more fuel to counteract this force. Aerodynamic design greatly benefits fuel economy.

An aerodynamically designed vehicle is also directly related to its maximum speed. Less drag means fewer forces opposing the vehicle's movement, allowing more engine power to be directed towards the movement of the vehicle.

During the 1980s, cars had substantial drag due to their boxy designs. In the 1990s, these boxy shapes were replaced with more aerodynamic forms, increasing top speeds with the same engines, suspensions, tires, and other components.



(Image Courtesy http://www.pagani.com/)

Lastly, vehicle aerodynamics can help reduce wind noise, lower noise emissions, and prevent undesirable lift forces and other instabilities at high speeds.

Please see ‘4.2.2 Drag Worked Examples’ pack for exam style questions.

For more revision notes, tutorials, worked examples and more help visit www.tutorpacks.co.uk.