Lesson 10.7 Terminal velocity and drag

Recommended teaching time for this lesson: 0.5 x 60 minute period

• 15 minutes of explicit teaching

• 15 minutes of suggested classroom activities

• 20 minutes homework

Getting started

Key ideas

* Terminal velocity is reached when a falling object stops accelerating.
* Drag force is the frictional force acting against an object moving through a fluid.

Curriculum links

Science understanding

* Identify forces acting on an object.
* Determine the resultant force acting on an object in one dimension.

Advice for teaching this lesson

Things to know before you start teaching

Terminal velocity is outside the scope of sequence of the senior syllabus and is not required to be taught. It has been left in the text as it provides a good introductory reading for a factor that students may wish to analyse as part of their student experiments if they are doing a topic related to some form of flight. Do not feel required to teach this. You can have students approximate a drag value for a system if they are doing a student experiment; however, there some errors with whatever method chosen that students should discuss as part of their evaluation.

Common misconceptions

* That drag is a fixed value for the entirety of flight. There is nearly no drag at the start of movement, and it changes through the whole system proportional to *v*2.

Differentiation strategies

Students who are exceptionally strong with mathematical approaches to physics may prefer to analyse this using a calculus form due to the drag force being a function of velocity which is also changing. If you have students who are struggling with this concept, just reassure them that the content is never on the exam and that they can ignore it.

Starter activity: Falling animals

Approximate time: 5 minutes

**Activity placement:** Place directly after Lesson overview

**Activity summary:** A quick question about how animals can fall safely while humans can’t.

Notes for the teacher

This video shows a rat falling from a three-story building and then running off. Please use best judgment on student sensibilities. The rat is unharmed.

You may prefer to just talk about it and ask students to consider if they’ve seen a cat jump from a building or tree without being harmed and run off.

Instructions for students

Step 1: Have you ever had a cat stuck in a tree just jump out and walk off with nothing wrong with it? Have you ever seen a video of a small animal falling from a height and then just running away unharmed? Watch the video below.

Rat jumps from 3-story building: <https://www.youtube.com/watch?v=dIKOLm3bQDU>

* 1. Propose a reason why the rat can fall from that height and run off, but you probably can’t.

Answers

1. The size and shape of the animal allows it to fall without harm. It reduces the maximum falling velocity so the impact is not as severe.

Classroom activity: Falling paper

Approximate time: 10 minutes

**Activity placement:** Place directly above “Real-world Physics: Surviving free fall”

**Activity summary:** An introduction to the drag equation.

Notes for the teacher

This activity will give students some practice with the drag equation. Note that this equation is not assessable in the syllabus.

If you do not teach this content, you may like to assign this activity to students who do a student experiment on projectile motion or gravity drops (alternative sequence).

The calculation itself is fairly simple, but students need to recognise that weight must equal drag at terminal velocity to start the calculation.

Students will need to work out some variables such as area or mass. They can do this with web research or using equipment in the laboratory.

Instructions for students

The equation below is the drag equation. It allows you to calculate the drag force (*F*D) for a given velocity (*v*).  
For this equation the new variables are:  
*ρ* – Rho (pronounced ‘row’) – is the density of fluid that the object is moving through. Note that air is a fluid because it flows. The units are in kg/m3.  
*C*D – Drag coefficient – this is a number based on the shape of the object. For example, a sphere has a coefficient of 0.47. This is a unitless number.  
*A* – Surface area – The surface area of the shape that is moving into the fluid. The units are in m2.

1. Calculate the terminal velocity for a flat piece of A4 paper falling to the ground. The drag coefficient for a rectangle is 2.1.

Helpful hints

* Consider what force is pulling the paper to the ground.

Support activity

Notes for the teacher

Provides some extra support on how to start the calculation.

Instructions for students

The equation below is the drag equation. It allows you to calculate the drag force (*F*D) for a given velocity (*v*).For this equation the new variables are:  
*ρ* – Rho (pronounced ‘row’) – is the density of fluid that the object is moving through. Note that air is a fluid because it flows. The units are in kg/m3.  
C*D* – Drag coefficient – this is a number based on the shape of the object. For example, a sphere has a coefficient of 0.47. This is a unitless number.  
*A* – Surface area – The surface area of the shape that is moving into the fluid. The units are in m2.

1. Calculate the terminal velocity for a flat piece of A4 paper falling to the ground. The drag coefficient for a rectangle is 2.1. A typical A4 piece of paper has a mass of 5 grams which will allow you to work out the weight of the paper.

Challenge activity

Notes for the teacher

This provides no given values and students will have to research them.

Instructions for students

The equation below is the drag equation. It allows you to calculate the drag force (*F*D) for a given velocity (*v*).  
For this equation the new variables are:  
*ρ* – Rho (pronounced ‘row’) – is the density of fluid that the object is moving through. Note that air is a fluid because it flows. The units are in kg/m3.  
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*A* – Surface area – The surface area of the shape that is moving into the fluid. The units are in m2.

1. Calculate the terminal velocity for a flat piece of A4 paper falling to the ground.

Answers

Support activity

Challenge activity