

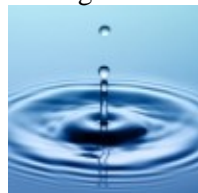


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June 2007

Package



Teacher package: Differential equations



This issue kicks off a brand new feature in *Plus*: the teacher package. Every issue will contain a package bringing together all *Plus* articles about a particular subject from the UK National Curriculum. Whether you're a student studying the subject, or a teacher teaching it, all relevant *Plus* articles will be available to you at a glance.

What do you think?

This is the first package in a new series for *Plus*, and we'd be very please to hear what our readers think. So if you are teacher, a student or any other interested *Plus* reader with thoughts on this new series, then please [get in touch](#).

Thank you!

Plus articles go far beyond the explicit maths taught at school, while still being accessible to someone doing A level maths. They put classroom maths in context by explaining the bigger picture they explore applications in the real world, find maths in unusual places, and delve into mathematical history and philosophy. We therefore hope that our teacher packages will provide an ideal resource for students working on projects and teachers wanting to offer their students a deeper insight in the world of maths. We start off our series with a package on differential equations.

Differential equations

One thing that will never change is the fact that the world is constantly changing. Mathematically, rates of change are described by derivatives. If you try and use maths to describe the world around you say the growth of a plant, the fluctuations of the stock market, the spread of diseases, or physical forces acting on an

Teacher package: Differential equations

object you soon find yourself dealing with derivatives of functions. The way they inter-relate and depend on other mathematical parameters is described by differential equations. These equations are at the heart of nearly all modern applications of mathematics to natural phenomena. The applications are almost unlimited, and they play a vital role in much of modern technology.

The *Plus* articles listed below all deal with differential equations. In some cases the equations are introduced explicitly, while others focus on a broader context, giving a feel for why the equations hold the key to describing particular situations. None of the articles require more than a basic understanding of calculus. All the articles come from our vast [archive](#), but whether they are feature articles, career interviews or news stories, they are all relevant, since today's news is tomorrow's standard result or technique. Take your pick.

- [Getting started](#) a quick recap on calculus and some articles introducing modelling with differential equations;
- [More applications](#) examples of differential equations at work in the real world;
- [Mathematical frontiers](#) mathematical developments, and the people behind them, that have contributed to the area of differential equations.

Getting started



[Making the grade](#) and [Making the grade: Part II](#) If you need to recap your calculus knowledge, these articles provide a quick introduction.



[101 uses of a quadratic equation: Part II](#) The quadratic equation is one of the mightiest beasts in maths. This article describes how several real-life problems give rise to differential equations in the shape of quadratics, and solves them too.



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Natural frequencies in music It takes vibrations to make sound, and differential equations to understand vibrations. The article uses Newton's second law of motion to model the behaviour of mass vibrating on a string.



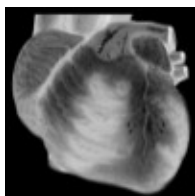
Have we caught your interest? Those who understand compound interest are destined to collect it. Those who don't are doomed to pay it. If you want to earn rather than lose, you need to understand the differential equations that are introduced explicitly in this article.

More applications of differential equations

...in medicine and nature



The mathematics of diseases Over the past one hundred years, mathematics has been used to understand and predict the spread of diseases, relating important public-health questions to basic infection parameters. This article describes some of the mathematical developments that have improved our understanding and predictive ability and introduces the differential equations involved.



Maths for the broken-hearted You take care of yourself – you eat right, don't smoke, drink in moderation and keep fit – but have you considered differential equations as a secret weapon in keeping you and your heart healthy?

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Chaos in the brain Saying that someone is a chaotic thinker might seem like an insult but it could be that the mathematical phenomenon of chaos is a crucial part of what makes our brains work. Chaos is all about unpredictable change and this can be described using differential equations.



How the leopard got its spots How does the uniform ball of cells that make up an embryo differentiate to create the dramatic patterns of a zebra or leopard? How come there are spotty animals with stripy tails, but no stripy animals with spotty tails? Get to know the equations that explain all this and more.



Going with the flow This article describes what happens when two fluids of different densities meet, for example when volcanoes erupt and hot ash-laden air is poured out into the atmosphere. The article explains Newton's second law of motion as a differential equation and its relation to fluid mechanics.



How plants halt sands Plants can stop the desert from relentlessly invading fertile territory. But just how and where should they be planted? A model involving differential equations gives the answers.



Fluid mechanics researcher Trying to solve differential equations can give you a stomach ache sometimes, but the equations can also help to prevent one. André Léger uses fluid dynamics to understand how food sloshes around the intestines.



Meteorologist If one thing is sure to change, it's the weather. Helen Hewson explains how she helps to predict it at the Met Office.

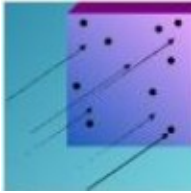


Universal pictures Partial differential equations explored through images: from the maths of turbulence to modelling human interaction.

...in physics and technology...



The dynamic Sun The Sun emits light from all across the electromagnetic spectrum and understanding its emission is essential in understanding solar dynamics. The article introduces the wave equation.



Light attenuation and exponential laws Many natural processes adhere to exponential laws. The attenuation of light the way it decays in brightness as it passes through a thin medium is one of them. The article explores the attenuation law of light transmission in its differential form.



Computer games developer In the real world, balls bounce and water splashes because of the laws of physics. In computer games, a physics engine ensures the virtual world behaves realistically. Nick Grey explains that to make the games, you need to understand the physics, and that requires differential equations.



Spaghetti breakthrough Differential equations model the breaking behaviour of pasta.

...in sport



If you can't bend it, model it! David Beckham and his fellow players may intuitively know how to bend a football's flight as they wish, but the rest of us have to resort to the differential equations describing the aerodynamics of footballs.

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Aerodynamicist The smallest alteration in the shape of a Formula One car can make the difference between winning and losing. It's the air flow that does it, so, as Christine Hogan explains, any Formula One team needs an aerodynamicist.



Formulaic football Mathematicians build a mathematical model of a football match.

...in finance



Financial modelling David Spaughton and Anton Merlushkin work for Credit Suisse First Boston, where they provide traders in the hectic dealing room with software based on complicated mathematical models of the financial markets. They explain how changing markets need the maths of change.



Financial maths course director Riaz Ahmad's mathematical career has led him from the complexities of blood flow to the risks of the financial markets via underwater acoustics differential equations help to understand all of these.



Project Finance Consultant Nick Crawley set up his own financial consultancy firm in Sydney, Australia, offering advice on large-scale financing deals. Understanding the risks of investments means understanding the fluctuations of markets, and that requires differential equations.

Mathematical frontiers



A differential story Peter D Lax wins the 2005 Abel Prize for his work on differential equations.



Count-abel even if not solve-able The 2004 Abel Prize goes to Sir Michael Atiyah and Isadore Singer for their work on how to solve systems of equations.



Plus is part of the family of activities in the Millennium Mathematics Project, which also includes the NRICH and MOTIVATE sites.