Differential Equations in introductory physics.

The purpose of the following is to use specific physics mechanics problems to motivate a consideration of the role and solution of 2nd order, linear differential equations with constant coefficients. Of course the acceleration "a" in Newton's 2nd law immediately leads to such a differential equation.

Problem: Chain falling off a pulley. 2nd order differential equation with constant coefficients.

Consider a chain of mass M, length L and density $\rho=M/L$. The chain is hung over an idealized pulley (frictionless, no moment if inertia, and negligible radius). Initially (at t=0) the chain is at rest and its long side hangs a distance x_0 lower than the unstable equilibrium distance L/2 below the pulley. Find the expression for the distance the x(t) that the long end of the chain moves down as a function of time.
For solution see:
http://www.physics.rutgers.edu/~croft/Diff-Eq-in%20-Phys/chain-pulley-diffeq.pdf

Problem: Spring, simple harmonic motion. 2nd order differential equation with constant coefficients.

Consider mass M, attached to a spring with spring constant k. Initially (at t=0) the mass is at rest and is displaced to its maximum amplitude x_0 from the stable equilibrium position x=0. Find the expression for the position of the mass, x(t) as a function of time.
For solution see: http://www.physics.rutgers.edu/~croft/Diff-Eq-in%20-Phys/SHM-diffeq.pdf
Actually before visiting the above review the discussion of complex variables at the link
http://www.physics.rutgers.edu/~croft/Diff-Eq-in%20-Phys/z-complex-var-impedance.pdf

Selected additional discussion of differential equations in introductory physics is at:
http://www.physics.rutgers.edu/~croft/Diff-Eq-in%20-Phys/z-differentialequations.pdf