1035-A0-2056 **Gilbert Strang***, Massachusetts Institute of Technology, Cambridge, MA. *Everyone Can Teach Applications.*

In linear algebra and equally in differential equations, second differences replace second derivatives. This is a terrifically valuable step in our three most basic courses:

Calculus: All students learn how dy/dx comes from $\Delta y/\Delta x$. Until they see a little more, they miss a crucial point. We can choose forward or backward or centered differences (and we do). For second differences the good choice has coefficients $1, -2, 1$ and a division by Δx squared. Why ?? This opens up a new understanding of y''.

Linear Algebra: My favorite matrices have $-1, 2, -1$ on the three center diagonals. I write them on the day I meet the class, and ask for their properties. (Symmetry is always the first answer.) Are they invertible: yes. What are their pivots, and determinants, and eigenvalues and eigenvectors ? All computations are beautiful, and these matrices are everywhere in applications—by their connection to $-y''$.

Differential Equations: Solving $y'' + y = 0$ is a pleasure. The solution is $y = \cos(t)$ if $y(0) = 1$ and $y'(0) = 0$. What happens when y'' is replaced by a second difference in scientific computing ? Again we have choices: Forward Euler, Backward Euler, Leapfrog, Trapezoidal Rule. Those four choices are controlled by their eigenvalues: Spiral out for $|\lambda| > 1$, Spiral in for $|\lambda| < 1$, Leap onto on ellipse or stay on a circle for $|\lambda| = 1$.

That choice is the reality of computational science. I will try to show why. (Received September 21, 2007)