# Intro to Lecture 10 Oct. 7, 2016

Last time, using the method of separation of variables to reduce a partial linear differential equation to a set of ordinary ones, we derived some important linear second order ordinary differential equations. In particular, we found the 1-D wave equation from using Cartesian coordinates and also for the azimuthal dependence in spherical and polar coordinates. From spherical coordinates we found the spherical Bessel equation and the associated Legendre equation, and from cylindrical polar coordinates we found the (ordinary) Bessel equation.

Then we asked how we might solve such equations, and suggested using expansions in infinite series, so we first defined convergence, absolute convergence, and uniform convergence, and introduced power series expansion.

Today we will explore the simple pendulum, which is not as simple as we thought as freshmen. We will consider a power series expansion taking account of the fact that the restoring force is not just linear in the displacement. This is an example of using series expansions for equations we can't solve in closed form. This particular example, the pendulum, will lead us to the complete elliptic integral of the first kind, and that will lead us more generally into elliptic functions, snu's and dnu's, *etc.*.

We will also consider power series expansions in $t$ for which the coefficients are functions of another variable, say $x$. This will bring us to generating functions, Bernoulli numbers and functions, the Riemann zeta function, and some formulae for numerical integration. The infamous Riemann zeta function has appeared several times on television shows, books and movies (Numb3rs, Sherlock, "A Beautiful Mind", "Life After Genius" ...).

- Project 1: It is due next Thursday. What are the groups? I tentatively have

  **A** Zongjie, XinYuan, Phillip

  **B** Hamza, Ross, Vlad, Abdul

  **C** Yuanwen, James

  but it would be better if one of B moved to C. Is that inappropriate?

- We will have a midterm on Wednesday Oct. 19. You are allowed two letter-sized sheets of paper with handwritten notes on them.

- Homework 5 (project was #4) is due Oct. 24