Institute for Mathematics and its Applications
2011 Seminar Series: 12
University of Wollongong

Title: Drilling odd n-gon holes and forced double-walled nanotube oscillators

Speaker: Barry J. Cox (University of Adelaide)

Time and Date: 11:30am, Tuesday, October 4, 2011

Location: Room 15.206

Abstract: Most of us are familiar with the problem of making circular holes in wood or other material. For smaller diameter holes we typically use a drill, and for larger diameter holes a spade-bit, hole-saw or plunge router may be used. However for some applications, like mortise-and tenon joints, what is needed is a tool that will produce a hole with a cross-section that is something other than a circle. In the first part of this talk we look at curves that may be used as the basis for a device that will produce holes with a cross-section of an equilateral triangle, square, or any regular polygon. The talk touches on basic algebra, geometry, calculus involved in showing these rotors exist for all regular polygons and also has connections to Gothic art and architecture.

In the second half of the talk we present a model for gigahertz oscillators comprising two coaxial carbon nanotubes of which the outer tube is fixed and the inner tube is allowed to freely oscillate due to the influences of van der Waals interactions and a sinusoidal forcing term. We examine the oscillatory behaviour predicted by the model in order to determine the role of forcing field strength and frequency has on the behaviour of the system. Neglecting any dissipative terms and thermal effects, we derive a model that may be solved analytically, region by region, and we use this solution to evolve numerical results for the model. This approach allows us to solve the model analytically and directly, thereby removing the need to solve the differential system of equations using a general numerical algorithm such as Runge-Kutta. The results for this model show that the induced amplitude and frequency are both functions of the forcing strength and forcing frequency. A number of regimes are identified and in the dominate regime we note the trend that increasing the forcing frequency leads to a decrease in the induced amplitude of oscillation and increasing the forcing field strength leads to a decrease in the frequency of the principal mode of induced oscillation. Another interesting phenomenon that is occasionally seen is highly ordered oscillations for extended periods. Although these very deterministic paths last for relatively long times (tens of nanoseconds), the order is sensitive to small perturbations to the initial conditions and in general atypical of the general behaviour which is more chaotic than deterministic.