<u>Room Resonances</u>:

Resonances in a room/auditorium that occur at certain specific frequencies are simply the result of 1-D, 2-D or 3-D acoustic standing waves in the room/auditorium, analogous to the standing wave resonances that occur in 1-D systems such as closed-closed organ pipes.

The details of solving the 3-D wave equation

$$\nabla^2 \vec{\xi}(x,y,z,t) - \frac{1}{v^2}\frac{\partial^2 \vec{\xi}(x,y,z,t)}{\partial t^2} = 0$$

$$\nabla^2 p(x,y,z,t) - \frac{1}{v^2}\frac{\partial^2 p(x,y,z,t)}{\partial t^2} = 0$$

for either the 3-D vector particle displacement amplitude $\vec{\xi}(x,y,z,t)$ and/or scalar over-pressure amplitude $p(x,y,z,t)$ in a 3-D rectangular box (*i.e.* a room) of dimensions {*L* x *W* x *H* } = {L_x, L_y, L_z}are discussed in detail on pages 3-7 of P406 POM lecture notes "Mathematical Musical Physics of the Wave Equation – Part 2". The boundary conditions are that the displacement amplitude $\psi(x,y,z,t)$ has nodes on the surfaces {the walls/floor/ceiling} of the room, whereas the over-pressure amplitude $p_o(x,y,z,t)$ has anti-nodes on these surfaces.

Because three spatial dimensions are involved in this problem, three integer indices {*l*, *m*, *n*} are required to uniquely describe the standing wave modes of the resonances in the room/auditorium. By convention, note that the {*x*, *y*, *z*} indices {*l*, *m*, *n*} are ordered strictly in decreasing room dimensions, *i.e*. by convention we have {$L_x \geq L_y \geq L_z$}.

There are 3 different basic types of modes of propagation of standing waves in a room.

a.) 1-D or so-called ***<u>axial</u>*** modes, simply associated with the 1-D wave equation.
b.) 2-D or so-called ***<u>transverse</u>*** modes, associated with the 2-D wave equation.
c.) 3-D or so-called ***<u>oblique</u>*** modes, associated with the full 3-D wave equation.

For example, the lowest three 1-D <u>axial</u> modes, [*xyz*] = [100], [010] and [001] or higher 1-D axial modes such as [*n*00], [0*n*0] or [00*n*] where integer *n* = 1, 2, 3, 4, 5, …. are 1-D standing waves in either the *x*, *y* or *z*-directions that exist between two opposing parallel walls (or *e.g*. ceiling & floor) that are separated by a distance L_x, L_y or L_z, respectively with corresponding frequencies $f_{n00} = nv/2L_x$, $f_{0n0} = nv/2L_y$ or $f_{00n} = nv/2L_z$. The 3 orthogonal axial mode paths that can be taken by such standing waves are indicated with arrows as shown in the figure below: