Learning Sequences arising from August 28, 2010, Zone Leaders Meeting at ISU

Learning Sequence #1:

	Discovery Learning	**Interactive Demonstration**	**Inquiry Lesson**	**Inquiry Lab**
Waves on springs/ropes/strings	Students develop an understanding of the nature of physical waves and wave propagation using a Slinky, rope, and string. Concepts of amplitude, frequency, period, and wavelength are developed using Slinky and given names using both transverse and longitudinal waves. Students relate period to frequency: $f = 1/t$. The effect of changing medium density is described based on wave propagation down a rope tied to a string. Students develop standing waves. (N.B. frequency and pitch are not identical, but will be treated as such here.)	Students observe the effect of changing tension, frequency (akin to pitch), and length on a stringed instrument to discover Mersenne's laws. Using Socratic dialogue and properly controlled demonstrations, the teacher gets the students to determine the general relationships between tension and frequency (e.g., the greater the tension the higher the frequency), between length and frequency (e.g., as length increase, the frequency decreases), and between linear density and frequency (e.g., the greater the linear mass density, the lower the frequency). The non-relationship of amplitude to other system variables is addressed.	Using a variable oscillator (whose frequencies are known) and a meter stick, student working under the guidance of the teacher conduct a controlled experiment to discover the inverse relationship between wavelength and frequency of standing waves on a string. Students conclude that the product of wavelength and frequency equals a constant. That is, $\lambda f = c$. Dimensional analysis is then used to show that the units of the constant are those of speed. Teacher draws parallels between v, d, and t, and wave counterparts to show that the constant, *c,* in the above equation equals speed of propagation. That is, $\lambda f = \lambda / t = d / t = v \equiv c$.	Students use dimensional analysis and the statement $\lambda = f(T, \mu, f)$ – this is, wavelength is a function of tension, linear mass density of the medium, and frequency – derived from observations to find the expected form of the relationship between variables. That is, $v = \lambda f = \sqrt{T/\mu}$. Students use an experimental set up in which they can control frequency, tension, and linear mass density of a string to confirm the expected form of the relationship.
	Hypothetical Inquiry:			

Learning Sequence #2:

	Discovery Learning	**Interactive Demonstration**	**Inquiry Lesson**	**Inquiry Lab**
Vibrating Columns of Air	Students are provided with bottles filled with different amounts of water, and asked to produce sound by blowing across the mouths of the bottles. Students work out the concept that the shorter the column of vibrating air, the higher the pitch of the sound generated. Students speculate as the source of the sound.	Students are introduced to various "slider toy" instruments or various brass and woodwind instruments and relate lengths over various open-ended air columns to the frequencies produced. Students compare and contrast the lengths of oscillating air columns and vibrating stings to see the parallels between propagation of oscillations and vibrations. Students use open-ended PVC pipes to play music by rapping pipes on palms of their hands.	Tuning fork held over top of an open-ended PVC pipe with one end immersed in water is used to show resonance phenomena. Students investigate ways to represent the motion of gas particles for standing waves in pipes. This is, they develop waveform representations.	Students use knowledge of waveform representations and an experimental setup consisting of tuning fork (of known frequency) and PVC pipe (open ends on tube with one end immersed in water) to find resonance points to determine the speed of sound in air. Speed of sound in air is derived from the relationship $\lambda f = v$.
	Hypothetical Inquiry:			