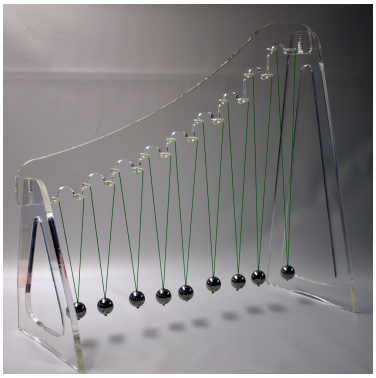

Pendulum Wave

P4-1755

PURPOSE:

Nine pendula, from a simultaneous start, display a captivating wave-like parade that shows all the possible phase relationships before returning to unison to start all over again. The pendula, each on a 2-line mount, make slightly less to slightly more than 20 swings in 20 seconds. Assembly of the device is an intended part of the learning and of the fun.

ASSEMBLY:

The first time the apparatus is used and each time it might have been disassembled, the notched pieces are connected, as in the illustration, to make an interlocking structure. The pieces fit very tightly but it should take only blows from the palm of the hand to drive them together. If the apparatus is disassembled repeatedly for storage, the fit might become loose, but this will not effect the performance.

On the top piece, 18 short pieces of rigid tubing are already installed. These will serve to give the swinging pendulum a knife-edge support and all measurements of pendulum length will be taken from the bottom of these tubes. The tubes will face forward, the lines will pass through the tubes to the back and they will be held in place by wedging a brass eyelet into each tube to hold the line. Extra line may be ignored or rolled up and taped in place. Once the adjustments are totally satisfactory, the extra line material may be cut away, if desired.

For each pendulum, a piece of line needs to be knotted in the middle to create two lines to hold the ball. Then pass the ends of the two lines through the hole in one of the balls. The lines are pulled so that the knot fits tightly to the bottom of the ball before passing each line through an appropriate tube. To hold the line in place, from the back, carefully insert the smaller end of a brass eyelet into the tube alongside the line, just enough to hold it in place. Mount all nine pendula in this way.

Place the Initiator plastic block on its side and place it where it will touch the balls. The eyelets protrude enough to be able to easily remove and replace them. Adjust the lines so that each pendulum hangs symmetrically, and the top edge of the stick touches the middle of the ball, before pushing the eyelet into place again. Leave the extra line or tape it to the back in neat coils. Do not cut any extra off at this time.

Using the following table, adjust the pendula to the lengths shown. It may take several preliminary trials to correctly establish the initial conditions for the apparatus. From the shortest, on the left side, to the longest, the pendula will in 20 seconds make the number of swings shown in the first column. The second column gives the calculated pendulum length, measuring to the bottom of the tube from the middle of the ball. The third column is left blank for the user.

Once the apparatus has been assembled, place the Initiator Stick against the pendula from the back side and uniformly displace all the pendula. By quickly removing the Initiator Stick, all the pendula begin to swing in phase. Since the periods differ, the phase relationship between pendula will change in a continuous fashion. This makes a compelling wave-like display during which attention can be drawn to the notions of length, period, phase, beats, vibrations and waves. After the pendula have been satisfactorily adjusted, the surplus line can be cut away and the eyelets pushed in firmly.

There is general agreement that the period of a simple pendulum, at small amplitude, depends only on the gravitational field and the length of the pendulum. In the following equation, T = the period in seconds, L = the length in meters, g = local acceleration of gravity in meters per second per second. "g" is usually taken as 9.8 unless a local value is known with more significant digits. The equation represents a good fit to experimental data as long as the amplitude is small.

$$T = 2\pi\sqrt{\frac{L}{g}}$$

Swings in 20s	Length (cm)	
24	17.2	
23	18.8	
22	20.5	
21	22.8	
20	**24.8**	
19	27.4	
18	30.6	
17	34.6	
16	38.8	