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Resonance pendulums - are an important addition to any introductory physics program. They incorporate the conservation laws of momentum and energy, and thus, lead to the concept of a simple perpectual motion machine. The pendulum is a simple, but fascinating, device. Identical pendulums are still simple but when paired (connected) become downright intriguing. Of course, when the concept of resonance (matching frequencies) is added to the mix, you have got a system of interaction that is nearly perfectly tuned; once started, it can go on for a very long time.

This piece of apparatus is usually homemade. I have tried to keep the design simple, to be made in a workshop with a small drill press to drill soft steel. (You may wish to contact a machine shop for this part; say that it's for "educational purposes".)

Construction: (a) Go to an iron works (yard) where they make (weld?) things out of iron. Ask for two pieces of soft steel, 4" x 2" x ½", for "educational purposes". (½" thick x 2" wide steel is fairly common stock.) If the 4" length of each is not exact, don't worry; it works out OK later.

(b) Drill a #7 hole 7/8" deep in the top of each steel bar. Thread each hole with a ¼"-20 tap. See diagram (b).

(c) Cut two ¼" dia. alum. rods 16" long. Thread one inch of one end of each rod with a ¼"-20 die. Carefully flatten one inch of the other end of each rod with a grinder or a file. Again, see diagram (b).

(d) Cut two 3" long pieces of old ½" wide hacksaw blade. Cut one 1/8" x 3/4" x 8¼" length of soft iron bar for the rocker arm. Drill the 1/8"dia. holes in the blades, bar, and Al rods for the 1/8" dia. pop rivets. See diagram (c).

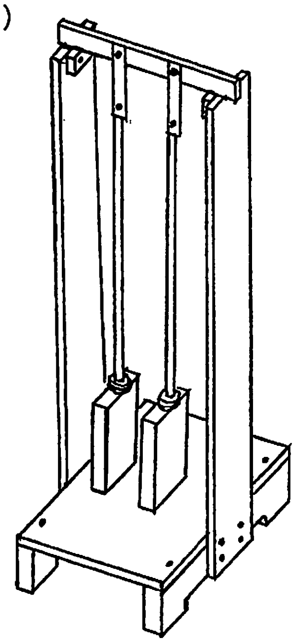
(e) Cut out the five wood boards for the base according to the diagram (d). Cut a small notch on top of each tall side piece; this could wait until later during final assembly.

(f) Cut out two short soft iron bars of 1/8" x 3/4" x 2" for the rocker arm bearing (pivot) points. See diagram (e). Use a 7/32" chainsaw file to make the small notches (pivot points). Drill the four 1/8"dia. passing holes in the two short bars to accept #4 x ½" RH wood screws.

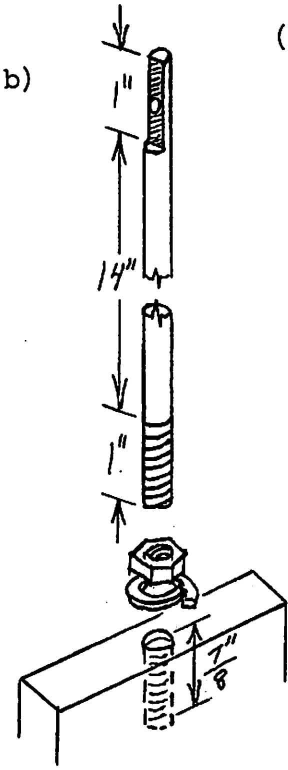
(g) Assemble the base with screws as shown in the diagram (a). Assemble the pendulums as shown. Locate the centers of mass of the pendulum bars via the "X" technique. See diagram (f). Adjust the bars on the Al rods until the y values are equal; tighten each ¼"-20 nut on each lock washer to "lock" the bars in place. Hang the rocker arm with pendulums on the bearing points.

Diagrams:

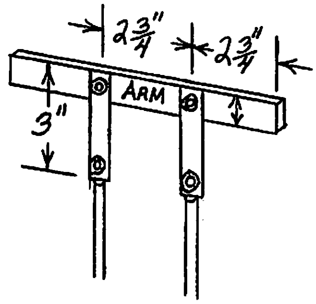
(a)



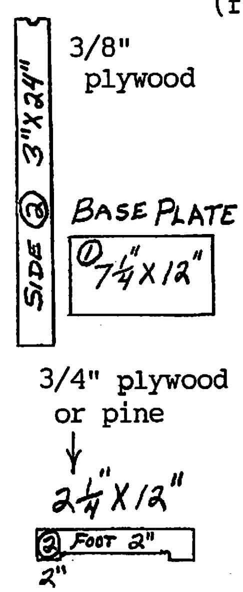
(b)



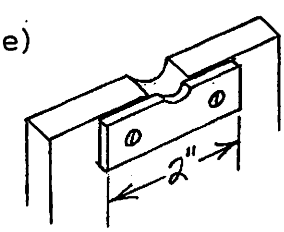
(c)



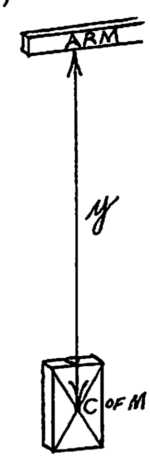
(d)



(e)



(f)



(h) Try out the system. Pull one pendulum back several inches, and let it go. Does its momentum and energy transfer smoothly to the other pendulum and back? Does it keep going smoothly for several minutes? If so, you now have a fine piece of apparatus to teach with!

(i) I especially recommend that you paint each iron bar a different color (red and bright green?) so the exchange is more visible to your students. Obviously, you may change anything in this writeup as you see fit.

Presentation: You choose the best time in your curriculum to bring this out and use it. You must also decide the sequence you wish to follow. You could start by bringing the pendulums back together and letting them go. Then bring each one back the same distance in the opposite direction and letting them go.

Finally, bring only one back, and let it go. Now you get the alternating reaction, the obvious transfer of momentum and energy without a collision as in Newton's "cradle". Instead, the transfer is via the hacksaw blades, the rocker arm, and resonance. It is so obvious as you watch the hacksaw blades bend (their elasticity) against the rocker arm.

Now if you go back to bringing each one back in the opposite direction and letting them go, the students can begin to understand that one pendulum is actually "feeding" (transferring to) the other. Repeat this part by bringing each back a different distance and letting them go; the "feeding" or transferring is very obvious.

I first saw and built this apparatus over 30 years ago, but I never tire of a great demonstration! Does this demo (apparatus) require some extra effort on your part? Yes. But things of value almost always require extra effort.