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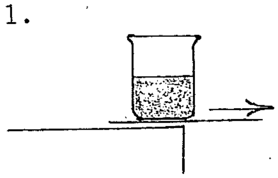
Keepers! I - A "keeper" is something having genuine and lasting merit; TPT magazine might call it a "little gem". By any name, simple, clever, reliable, handy demonstrations that fall into this catagory are many and growing and are highly favored by physics demonstrators. I will describe a few of my favorites that have served me well over the years.

(a) Inertia - When introducing Newton's first law on inertia, this demo has never failed. It requires a smooth, dry table top, a clean, dry sheet of copy paper, and a dry, smooth-bottomed 800 or 1,000 ml beaker with about 300-400 ml of water in it. Complete dryness of all contact surfaces is paramount. To demonstrate, place the beaker with water on the paper near one end. Take the other end and slowly drag the sheet and beaker across the table top until its edge is reached. Carefully pull the sheet a little more so the edge of the beaker is slightly beyond the edge of the table (1.). (At this point, the students are usually fully engaged.) With a quick snap outward, pull the sheet out from under the beaker. It's not as elaborate as a table setting on a table cloth but just as effective. Of course, there are many other demos on the same theme.

(b) 2-D motion - When introducing 2-D motion, a toy store "ping-pong" pistol can be quite useful; spring-loaded, it shoots out plastic spheres (2.). One version has different spring tension settings to provide different "muzzle" velocities. At any setting, the accelerating force is reproducible, thus quantitative as well as qualitative. Aimed to horizontally or at any angle other than horizontal, it will demonstrate gravity's effect on free flight in spite of considerable air resistance (drag) on the projectile. It works well to show that 45° is the optimum angle for maximum horizontal distance for a given muzzle velocity. Students (and teachers) love toys; they are definite attention-getters.

1.



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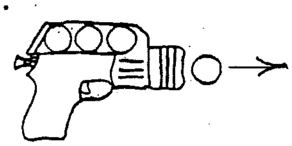

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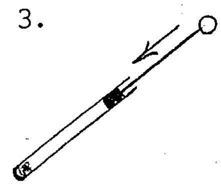

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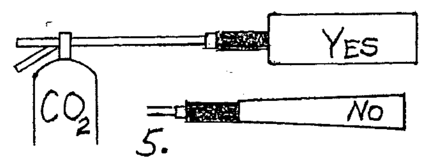


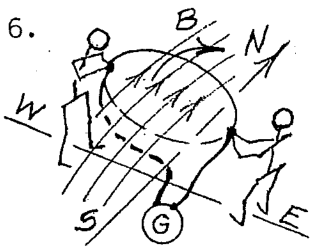
(c) Adiabatic processes (the compression and expansion of gases and the corresponding temperature changes) - The fire syringe and the CO_2 fire extinguisher demonstrate these processes extremely well. The fire syringe, a piston-cylinder apparatus, is a commercial product (3.). It uses adiabatic compression, that is, a tight-fitting piston quickly shoved downward in a cylinder, to ignite a mixture of oxygen and a piece of kleenex dampened in lacquer thinner, etc. As a result of the work done on the piston, thus, on the gas mixture, the temperature in the cylinder soars to the flash point of the mixture and a small explosion (flash) occurs. Often it does not fire on the first or second plunge; immediately remove the piston completely allowing fresh air to enter the cylinder and plunge again. Each time you plunge you are raising the temperature within the cylinder. By the third or forth plunge, it should fire. (Also, the thinner-oxygen "mixture" may be improving.) With practice, the demo will become more reliable. It is worth the effort; it is dramatic.

The carbon dioxide (CO_2) fire extinguisher performs its important function via adiabatic expansion, allowing its greatly compressed gas (actually in liquid form) to suddenly expand into our relatively "low pressure" atmosphere. This tremendous expansion simultaneously initiates a tremendous drop in temperature which in turn lowers the fire's temperature, thus, toward extinguishing it. (The heavier than air CO_2 also "blankets" the fire cutting off it oxygen supply or suffocating it.) The liquid CO_2 in the tank is at room temperature, 20°C or 68°F. When it is suddenly released under the right conditions, the temperature of the CO_2 can drop to -79°C or -109°F, the temperature of dry ice (and its flakes), and it only takes a fraction of a second. Doing the math, the CO_2 temp. drop is $\propto$100°C or $\propto$180°F; astounding! The "right conditions" requires the right type of "horn" on the extinguisher. It must be the large "cylinder" type (4.), not the "tapered" type (5.). Look around your building and swap for one , if possible. Notify your safety official after use for a prompt refill (safety first!).

Presentation: In this case, two closely related demos "add up" to one very special demo. Start with the syringe, followed closely by the extinguisher. The syringe shows that a sudden increase in pressure causes a sudden increase in temperature. The CO_2 extinguisher shows just the opposite, that a sudden decrease in pressure causes a sudden decrease in temperature. After the syringe has been demonstrated, grab the extinguisher and announce that if the Lord won't provide snow for the students' winter sports, their physics teacher will! Parade around the room singing "Let it snow, let it snow!" releasing a few blasts of dry ice flakes into the air above the students. The flakes will drift down and sublimate. Blast a table top to see many flakes together; the students nearby will feel the sudden cold. Limit the extinguisher's use for safety reasons (suffocating your students?). Immediately after the extinguisher's use, note the white frost (condensation) on the black horn from some of the moisture in the room.
How are these demos related to real life? The syringe demonstrates the principle behind the diesel engine which doesn't require spark plugs for ignition, just a "glow" plug. The extinguisher demonstrates the lower temperatures experienced at higher elevations and altitudes where there is lower air pressure.

(d) Electromagnetic induction - The "jump-rope generator" (6.) uses the earth's magnetic field to generate AC electricity, however small, via electromagnetic induction. All that's required are three students, a #16, 3-wire, 12-15' extension cord (3 times the wire!), special male and female plugs (7.), a galanometer, and a compass. Make up the plugs as illustrated in 7.

6.



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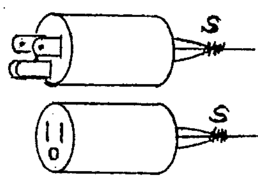
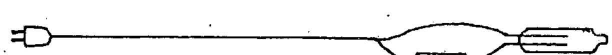


Solder(s) the 3 wires together to the one going to (G).

Presentation: This demo will require a large space so the students will have adequate room to twirl the extension cord. The compass will help determine the best positions for the students to stand, at 90° (right angles) to the earth's magnetic field, for best results. The third student will monitor the galvanometer. If an analog (needle) galvanometer is used, the students twirling the cord, with the help of the monitor, should try to find a "twirl-rate" that possibly matches the needle's AC "flex-rate"; this exercise would produce the maximum needle deflection (best observation). Regardless, the needle will move and/or quiver if any electricity is generated due to the twirling.

(e) AC electricity - As the electronic age began to assert itself in the '70's and '80's, new products became available that provided new possibilities for demonstrators. First came the Ne-2E or N-2 neon lamp (bulb) (8.) followed by the Bicolor LED, R & G (9.). If these lamps are soldered to old #18 lamp cords about 3' long with the proper protective resistors in series, 60 cycle AC electricity can be revealed in a very simple way. (With proper care, they should last indefinity.) To demonstrate, simply move the lamps quickly back and forth and whirl them in a vertical circle. Each effect is dramatic! Note the yellow ("mixed") light of the Bicolor LED when it is stationary.

8.



Ne-2E or N - 2 lamp

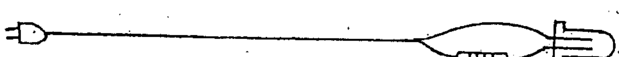
120V

56KΩ resistor

An N-2 lamp behaves like a rectifier or lights up in one direction only and above 65V, thus, providing an unlighted space when you move the lamp and the current is in the opposite direction. Solder the resistor in series as shown.

Warning - Both of these lamps are using 120 VAC. For safety in handling, insulate properly!

9.



Bicolor LED, R & G

120V

22K Ω resistor

The Bicolor LED will light up red in one direction and green in the other. Solder the resistor in series as shown. Always keep the use time short to protect the LED and the resistor.

(Thanks goes to Harry Rheam of NJ for sharing the 22KΩ resistor idea.)